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AD 863684

FLEXIBLE ROLLED-UP SOLAR ARRAY

SIXTH QUARTERLY REPORT

JANUARY 1970

PREPARED FOR:
Air Force Aero Propulsion Laboratory
Research and Technology Division
Wright-Patterson Air Force Base, Ohio 45433

PROJECT NO. 682J/DATA NO. HS207-205(6)/CONTRACT NO. F33615-68-C-1676

PREPARED BY:
Hughes Aircraft Company / Space Systems Division
(Under Contract F33615-68-C-1676)

AUTHORS: E. O. Felkel
G. Wolff
Et al.

Hughes Ref No. 70(22)-7658/B3532-008

SSD 00021R

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FOREWORD

This report was prepared by Hughes Aircraft Company, Space Systems Division, El Segundo, California, under Contract F33615-68-C-1676. The work was administered under the direction of L. D. Massie, APIP-2 Air Force Aero Propulsion Laboratory.

The period covered extends from 29 September to 21 December 1969. Contributors to this report include E. O. Felkel, G. Wolff, M. C. Olson, W. N. Turner, R. E. Daniel, G. P. Steffen, D. Plummer, R. K. Geiser, D. Garth, C. Duncan, and D. Lane, all of Hughes Aircraft Company, Space Systems Division, El Segundo, California.

The work covered herein was accomplished under Air Force Contract F33615-68-C-1676, but this report is being published and distributed prior to Air Force review. Publication of this quarterly, therefore, does not constitute approval by the Air Force of the findings or conclusions contained herein. It is published for the exchange and stimulation of ideas.

ABSTRACT

The main activities on the Flexible Rolled-Up Solar Array (FRUSA) program during the sixth quarterly reporting period consisted of completion of the detailed drawings of all the FRUSA components. Most of the drawings have undergone stress and dimensioning checks and have been released to manufacturing for procurement or fabrication of components and parts. The supplier of the boom actuator mechanism has completed final tests of the development test unit prior to shipment of the unit. The unit was received by Hughes on 20 December 1969. The solar cell manufacturer has fabricated the cell qualification lot and is on schedule for the required January delivery of the first qualification model cells. The average power output is slightly higher than the specified value.

Test and development programs on various system components including panel roll-up, cushion, panel thermal shock, and battery/charge controller have been successfully completed. Design reviews on each of the FRUSA subsystems were held prior to initiation of the qualification model drawing release phase which was initiated during this reporting period. The design of the subsystems was deemed to be satisfactory.

A Preliminary Qualification Test Plan has been completed and the Quality Assurance section of Specification DS 30992-001 "Performance, Design, and Product Confirmation Requirements for HS-207 Flexible Rolled-Up Solar Array Experiment, Qualification Model" and of the "Performance, Design, and Product Confirmation Requirements for HS-207 Flexible Rolled-Up Solar Array Experiment, Flight Model" have been completed and submitted to Wright-Patterson Air Force Base for approval.

A series of meetings were held at SAMSO and Aerospace on 13 and 14 November 1969. The purpose of the meetings was to familiarize the attendees with the plans of the 71-2 flight and to update each experiments' requirements document. These documents have been included in the RFP issued by SAMSO on 16 December 1969 for the integration of four experiments, including FRUSA, and for furnishing the spacecraft.

CONTENTS

ILLUSTRATIONS

TABLES

SECTION I

INTRODUCTION AND SUMMARY

This document reports the progress in the sixth quarter (29 September to 21 December 1969) on AFAPL contract F33615-68-C-1676, Flexible Rolled-Up Solar Array, Project Number 682J.

The main activities on the Flexible Rolled-Up Solar Array (FRUSA) program during the sixth quarterly reporting period consisted of completion of the detailed drawings of all the FRUSA components. Most of the drawings have undergone stress and dimensioning checks and have been released to manufacturing for procurement or fabrication of components and parts. The supplier of the boom actuator mechanism has completed final tests of the development test unit prior to shipment of the unit. The unit was received by Hughes on 20 December 1969. The solar cell manufacturer has fabricated the cell qualification lot and is on schedule for the required January delivery of the first qualification model cells. The average power output is slightly higher than the specified value.

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The format of this report is designed to present the status of each major system element in a separate section.

SECTION II

PROGRAM STATUS

The Flexible Rolled-Up Solar Array (FRUSA) program is divided into five phases, as described in the paragraphs that follow. The current program schedule and status are shown in Figure 1.

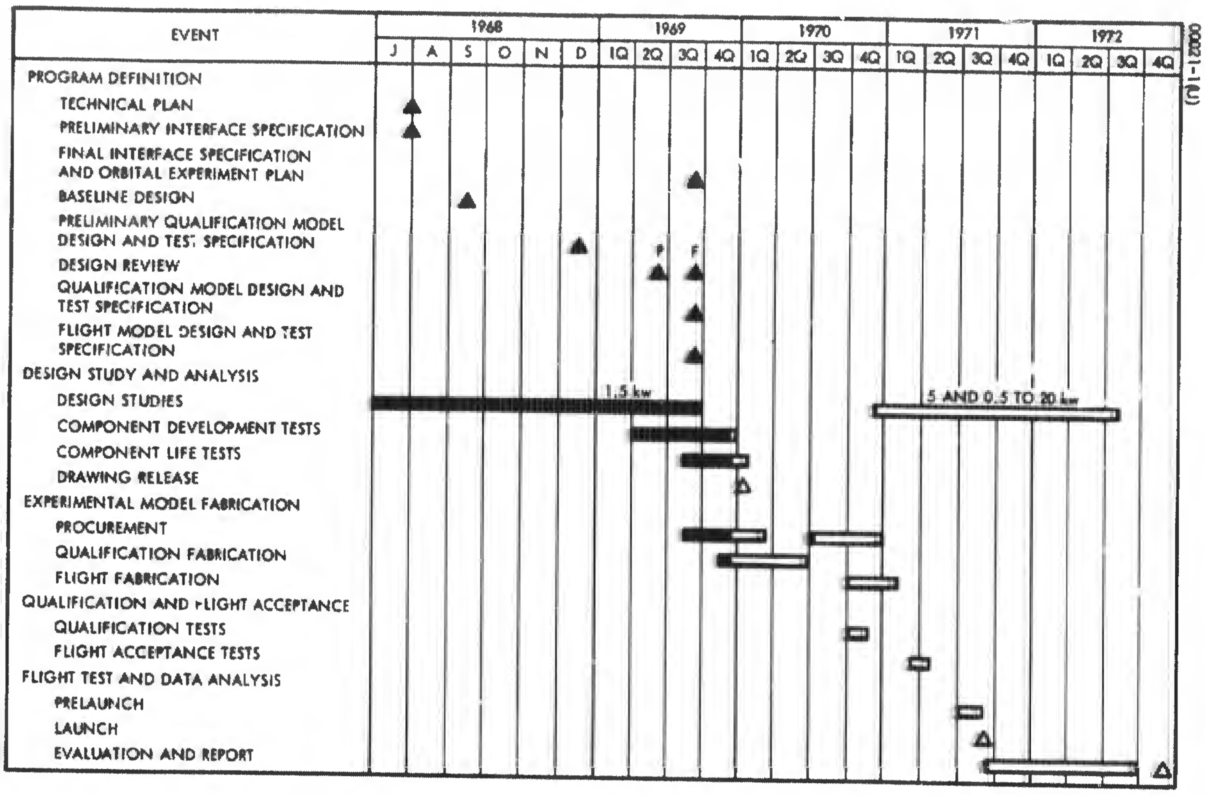

Figure 1. Program Schedule

PHASE I — PROGRAM DEFINITION

Major milestones associated with this phase and scheduled during this period have been completed. Included in this category are all the program requirements, design, and test requirements.

PHASE II – DESIGN STUDY AND ANALYSIS

The study phase of the program has been completed and a firm baseline design established. Design packaging and formalization of the system test plan details are continuing.

PHASE III – MODEL FABRICATION

SPAR Aerospace Limited, Canada, shipped the engineering/qualification model boom actuator assembly to Hughes on 19 December 1969.

Fabrication of the engineering/qualification model drum mechanism has started. Procurement of the qualification unit material is proceeding on schedule. Engineering drawing release will be completed by 21 January 1970.

PHASE IV – QUALIFICATION AND FLIGHT ACCEPTANCE TESTS

Qualification and flight acceptance tests will be conducted according to the test plan.

PHASE V – FLIGHT TEST AND DATA ANALYSIS

The flight test and data analysis phase will include prelaunch checkout and countdown procedures, as well as in-orbit operation and analysis.

SECTION III

SYSTEMS ENGINEERING

DOCUMENTATION

The Quality Assurance section of Specification DS30992-001 "Performance, Design, and Product Confirmation Requirements for FRUSA Experiment, Qualification Model" (and the complementary document for the flight model also) have been updated to reflect current test program philosophy. Originally, a total of 500 extension/retraction cycles under ambient conditions was planned and thermal testing included only a thermal vacuum environment. Subsequent reevaluation has indicated that 500 extension/retraction cycles is excessive and further that a need exists for solar thermal vacuum testing. Therefore, the extension/retraction requirement has been reduced to 25 and solar simulation has been added as an environmental requirement.

The FRUSA system power summary was updated. This document lists all power loads and heat dissipation for all orbital conditions. The most important parameter in this document is the battery energy required during the longest eclipse. The present figure is 57.3 ampere-minutes. Assuming a conservative battery charge efficiency of 58 percent, 98.8 ampere-minutes of charging energy is required during the illumination period to replenish the battery during each orbit. Since each battery is charged at a 1 ampere rate which provides 57 ampere-minutes into each battery for a total of 114 ampere-minutes, an ample energy margin exists.

A preliminary cable interconnection drawing for the FRUSA units mounted on the Agena orbital equipment rack has been prepared. This drawing shows interconnections between the power conditioning unit, battery charge controllers, load bank, Agena telemetry subsystem, Agena command decoder, and the Agena power subsystem.

MEETINGS

A series of meetings were held at SAMSO and Aerospace on 13 and 14 November to finalize FRUSA requirements for the vehicle integrating contractor. The most important potential problem was that of depleting the FRUSA batteries after launch because the solar array might not be deployed and extended for a period of time that could be as long as 48 hours. This matter was resolved by deciding to launch the FRUSA experiment in a nonoperative condition with the batteries disconnected. A battery disconnect

switch will be provided by the vehicle integrator to turn on the FRUSA experiment shortly before array deployment and extension. This will eliminate the requirement to install a battery flight plug prior to launch.

COMMAND LIST

Two commands have been added recently to the command list: Nos. 37 and 38. These were added to allow individual turnon and turnoff of each battery/charge controller. Previously they were turned on and off together. Table I lists all current commands required from the Agena command decoder.

FRUSA WEIGHT SUMMARY

A current system weight summary is shown in Table II. The weight saving of 3 pounds reflected in Category I of the table has been realized in the control and avionics equipment of the orientation mechanism.

WORK TO BE PERFORMED DURING NEXT REPORT PERIOD

1) Continue to update performance requirements, interface requirements, and space experiment plan to reflect latest design changes and mission plans

2) Update FRUSA system power summary to document all power loads and heat dissipation for all launch and orbital configurations

3) Continue to update FRUSA system grounding and return diagram

TABLE I. COMMAND LIST

Command	Command Function
1	Manual torque support (X) axis, OFF/POSITIVE
2	Manual torque support (X) axis, OFF/NEGATIVE
3	Manual torque drum (W) axis, OFF/POSITIVE
4	Manual torque drum (W) axis, OFF/NEGATIVE
5	Control electronics unit, OFF/ON
6	Limit override, OFF/ON
7	Solar array power switch, DISABLE
8	Solar array power switch, ENABLE
9	Overvoltage/undervoltage override, OFF
10	Overvoltage/undervoltage override, ON
11	Solar array extend
12	Solar array retract
13	Solar array motor, DISABLE
14	Solar array motor, ENABLE
15	Battery 1 charge, DISABLE
16	Battery 1 charge, ENABLE
17	Load bank 1, ON
18	Load bank 2, ON
19	Load bank 3, ON
20	Load bank 4, ON
21	Load bank 1, OFF
22	Load bank 2, OFF

Table I (continued)

Command	Command Function
23	Load bank 3, OFF
24	Load bank 4, OFF
25	Sun lockon override, ENABLE
26	Sun lockon override, DISABLE
27	Release and extend logic override, ENABLE
28	Release and extend logic override, DISABLE
29	Retract logic override, ENABLE
30	Retract logic override, DISABLE
31	Manual sun lockon, OFF/ON
32	Spare
33	Torquer drive, OFF/AUTO
34	Solar cell electronics unit, OFF/ON
35	Battery charge cutoff override, ENABLE
36	Battery charge cutoff override, DISABLE
37	Battery 2 charge, DISABLE
38	Spare battery 2 charge, ENABLE

TABLE II. FRUSA FLIGHT WEIGHT SUMMARY

Category	Subsystem	Weight, pounds		
	Orientation Linkage			
	Structure		20.27	
	Controls and avionics		17.14	
	Motors and tachometers	8.14		
	Sun sensors	1.0		
	Electronics	8.0		
	Power and signal transfer		8.60	
	Sliprings/brushes	6.6		
	Wire and connectors	2.0		
	Subsystem total			46.01
	Solar Array			
	Solar array panel		34.76	
	Cells with covers	28.90		
	Cells Z-strips	1.60		
	Fiberglass and adhesive	1.34		
	Kapton substrate	1.41		
	Power bus	1.51		
	Array cushion, reel, and drive		3.17	
	Drum mechanisms		32.69	
	Drum, spar, thermal covers, and OLSCA mounting support	10.64		

Table II (continued)

Category	Subsystem	Weight, pounds		
	Actuators	17.00		
	Power harnesses and hardware	2.85		
	Boom length compensators	0.68		
	Spreader bar	1.52		
	Subsystem total			70.62
	<u>Power Conditioning and Storage</u>			
	Batteries/controllers		42.0	
	Power conditioning		13.5	
	Subsystem total			55.50
	<u>Instrumentation</u>			9.38
I	<u>FRUSA System Total</u>			181.51
II	<u>Solar Cell Reference Modules</u>			
	Commutator, electronics connectors			4.47
III	<u>Installation Equipment</u>			38.92
	Load bank		35.00	
	Orbital rack fittings		3.92	
IV	<u>Contingency</u>			25.10
	Total flight weight			250.00

SECTION IV

SOLAR ARRAY SUBSYSTEM

SUBSYSTEM DESCRIPTION AND STATUS

The solar array subsystem consists of two flexible solar cell arrays that are stored, deployed, and retracted by the drum mechanism (Figure 2).

The following significant items and tasks were accomplished during the sixth quarter of the program:

1) Completion of detail drawing release for the flight and qualification model of drum mechanism

2) Start of part fabrication for qualification model of drum mechanism

3) Completion of detail drawings of solar panels

4) Completion of 75 additional thermal shock cycles of sample solar array

5) Start of bearing and negator development tests with revised bearing installation

6) Completion of panel roll-up evaluation program

STORAGE DRUM MECHANISM

Design Task

The final premanufacture design review on the solar array subsystem was held on 5 November 1969. The following action items were generated:

- Request to reduce panel tension by modifying the drum negator drive. An analysis of this request has indicated no change is necessary or appropriate at this time.

- Request to analyze strength characteristics of a thin-wall storage drum versus current lightening hole configuration. A tradeoff study has shown that the current design has higher strength and stiffness than the equal weight thin-wall design.

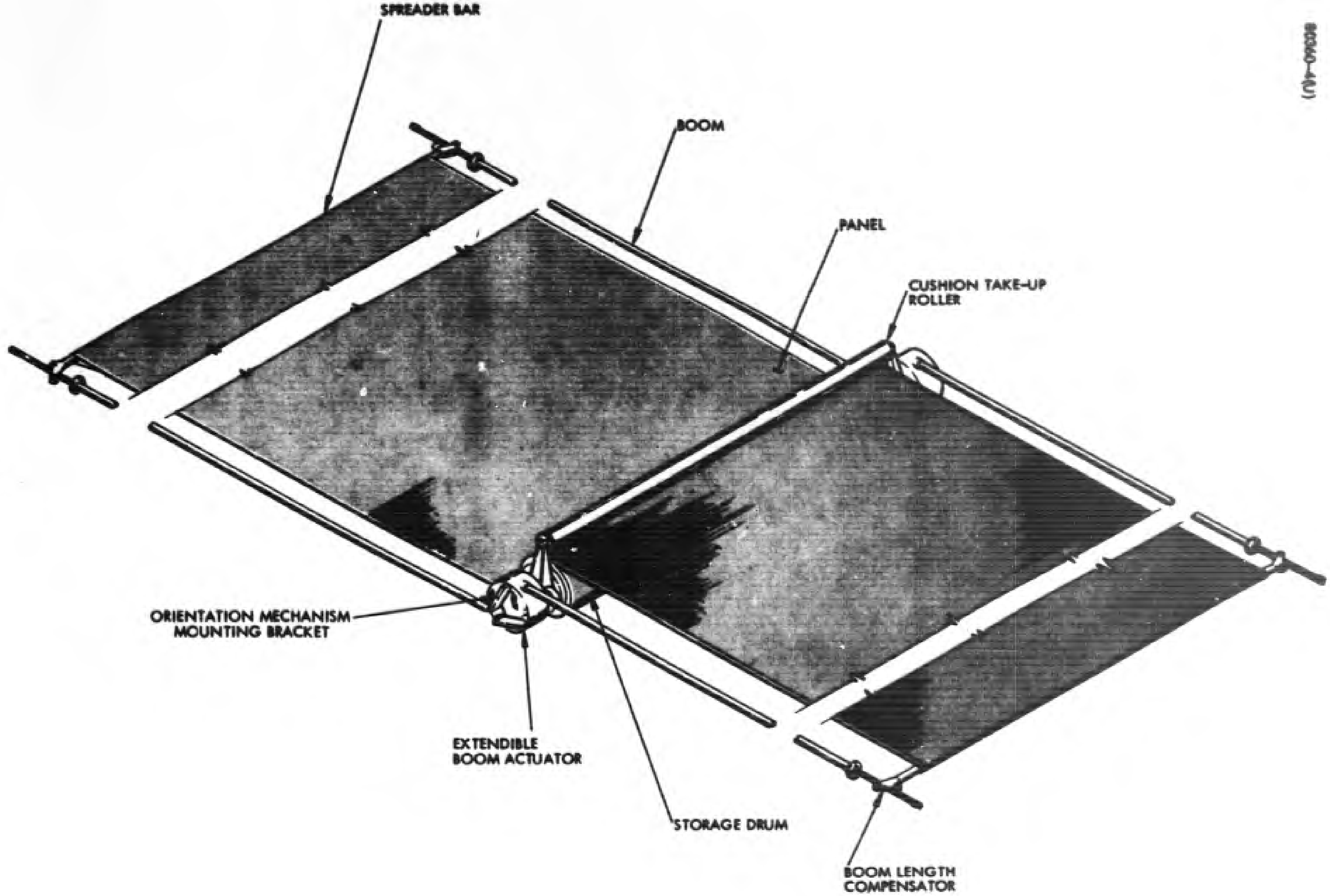

Figure 2. Solar Array Subsystem

In addition to an overall review of the design, a separate in-depth review was conducted on the drum bearing installation. The conclusion drawn from this review was that the present bearing installation design is suitable for the expected temperature ranges and the differentials between housing and shaft.

The detail drawings of the basic drum mechanism have been released. Work is still continuing on the assembly drawings and some installation hardware for the instrumentation subsystem.

Bearing and Negator Development Tests

Incorporation of new detail parts to reflect the current bearing installation has been completed. These parts have been changed to titanium in order to match the thermal expansion coefficients of the stainless steel bearings. An additional stiff spring in the form of a wavy washer is also being incorporated into the test equipment to eliminate potentially high preload changes. Both high and low temperature tests will be run after completion of preliminary room temperature measurements. It is planned that both the cushion reel and the storage drum negators will be evaluated along with the bearings.

Boom Actuator Unit Development

The boom actuator units being built by SPAR Aerospace have performed within specification in all development tests except the boom bending instrumentation calibration and the straightness and alignment evaluation. Review of data taken during these tests has revealed the following:

- Boom Straightness and Alignment — The data indicate the misalignment in the vertical plane is acceptable for the system since each pair of booms are misaligned in the same manner. That is, the booms for panel No. 1 are bowed in the same direction with very little difference between their respective profiles. The misalignment in the horizontal plane also appears to be acceptable. Maximum misalignment in this plane is about 2 inches. Since the force required to move the boom tip this 2 inch distance is negligible, the increased load on the boom length compensator bearings is not expected to be significant. In conclusion, the engineering/qualification model straightness and alignment is deemed to be acceptable as is. Procurement specification changes will be made following the engineering test program at Hughes.

- Boom Bending Instrumentation — The test results have indicated that the sensitivity of the boom bending instrumentation is about half the specification requirement. This is not considered a serious problem since the gain of the strain gage amplifier can be adjusted to compensate. It has also been decided that this instrumentation will be used primarily for static measurements rather than dynamic measurements. Because of this change in basic philosophy, the range of measurement capability is being expanded from 47 to 100 in-lb. SPAR is modifying the design to accommodate this extended range.

A test to determine the effect of extension limit switch failure is being planned by SPAR Aerospace. This test will be performed on the single boom breadboard unit. Results will be available during the next reporting period.

Another task currently being performed by SPAR Aerospace is the addition of a silver plated stainless steel boom element sample to the engineering/qualification model. The sample piece will be a Bi-STEM element approximately 2 inches long. Reflectivity measurements will be made periodically to determine the effect of the test and storage and handling environment on the silver plating thermal characteristics.

FLEXIBLE SOLAR ARRAY

Design Task

The detail and assembly drawings of the solar panel have been completed. These drawings include the recently added reference cell/modules. A detailed dimensional check and stress analyses of these drawings is in progress.

In addition, the tooling design task for solar panel assembly and test has begun. This tooling consists of tables for vacuum bonding operations, fixtures for cell placement on panel, and supporting apparatus for electrical checkout of panels.

An analysis has been completed to obtain the optimum load resistances for generating the reference cells/modules voltage, current curves. The values chosen are illustrated in Figures 3 and 4.

Panel Segment Thermal Shock and Cycling Tests

A total of 100 thermal shock cycles have been imposed on a representative panel segment (Figure 8 — Fifth Quarterly Report). These cycles have covered the temperature range of about +200 to -300°F. Although no electrical degradation resulted after 25 cycles, one cell group showed physical damage at a negative and a positive contact, both at terminal ends of the cell group. After 100 cycles, however, the other cell group showed electrical degradation resulting from a fracture across a cell at the negative contact. This cell also was positioned at the terminal end of cell group. Fractures noted are believed to be the result of excess solder on contact areas. Quality control procedures have been established to eliminate this failure mechanism by establishing tighter inspection procedures. Further tests are planned.

Cushion Development

Full width cushion development has begun using the setup shown in Figures 5 and 6. The first samples tried exhibit excellent embossment but have more tears than expected. An investigation is in progress to determine the reasons for the tears and methods for improvement.

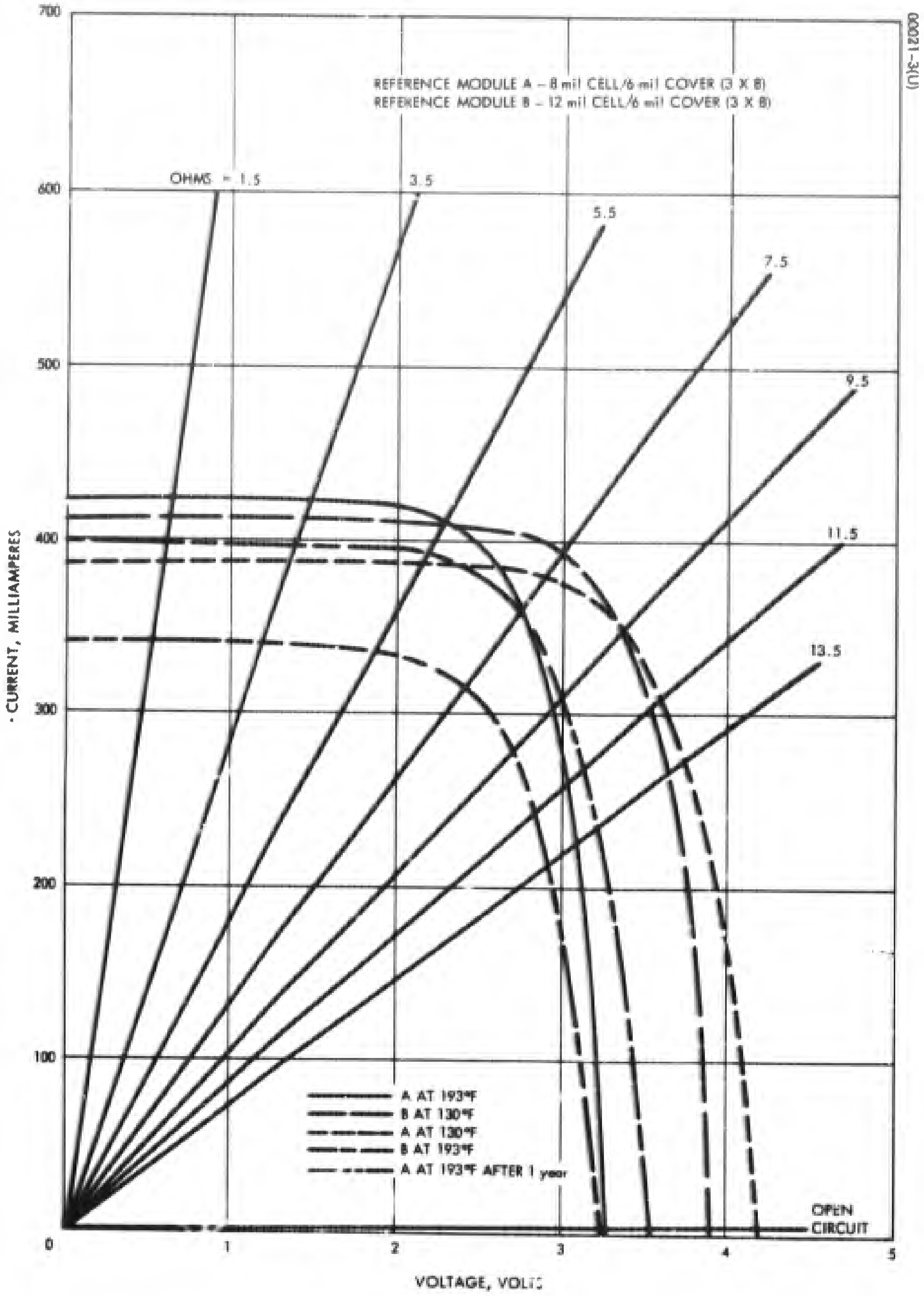

Figure 3. Current Voltage Curves for Reference Modules

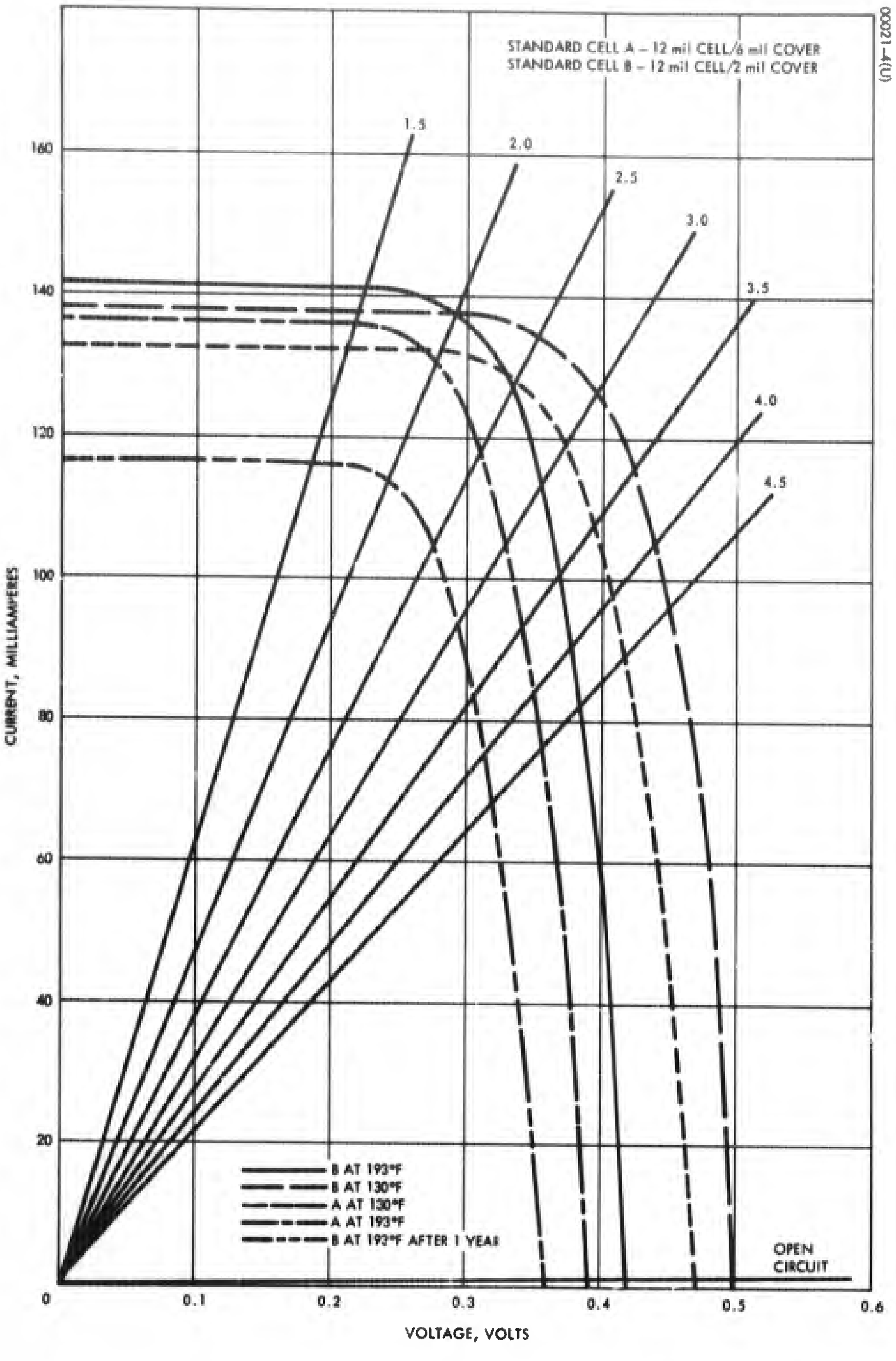

Figure 4. Current Voltage Curves for Reference Cells

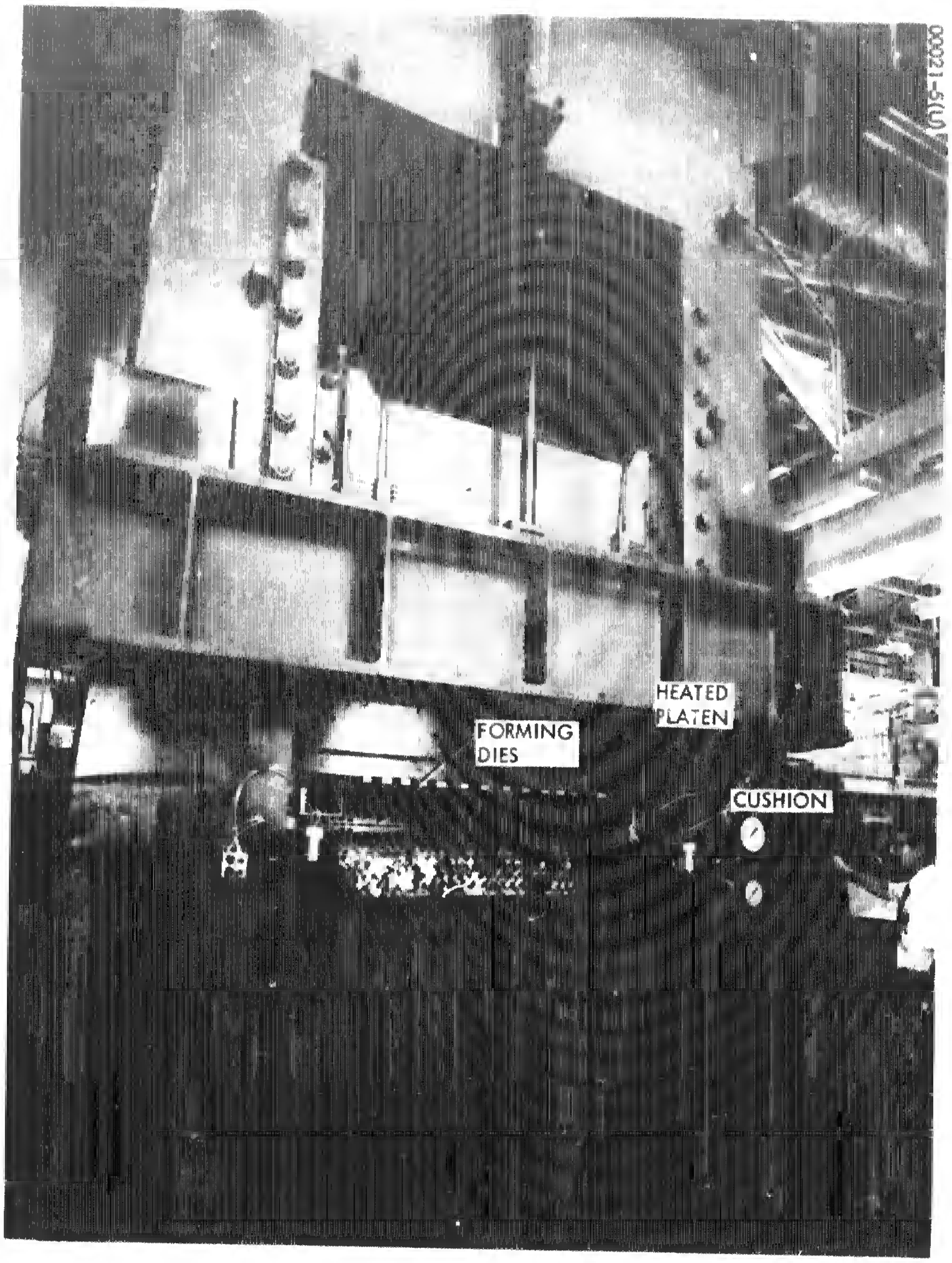

Figure 5. Cushion Fabrication Equipment
(Photo 4R11804)

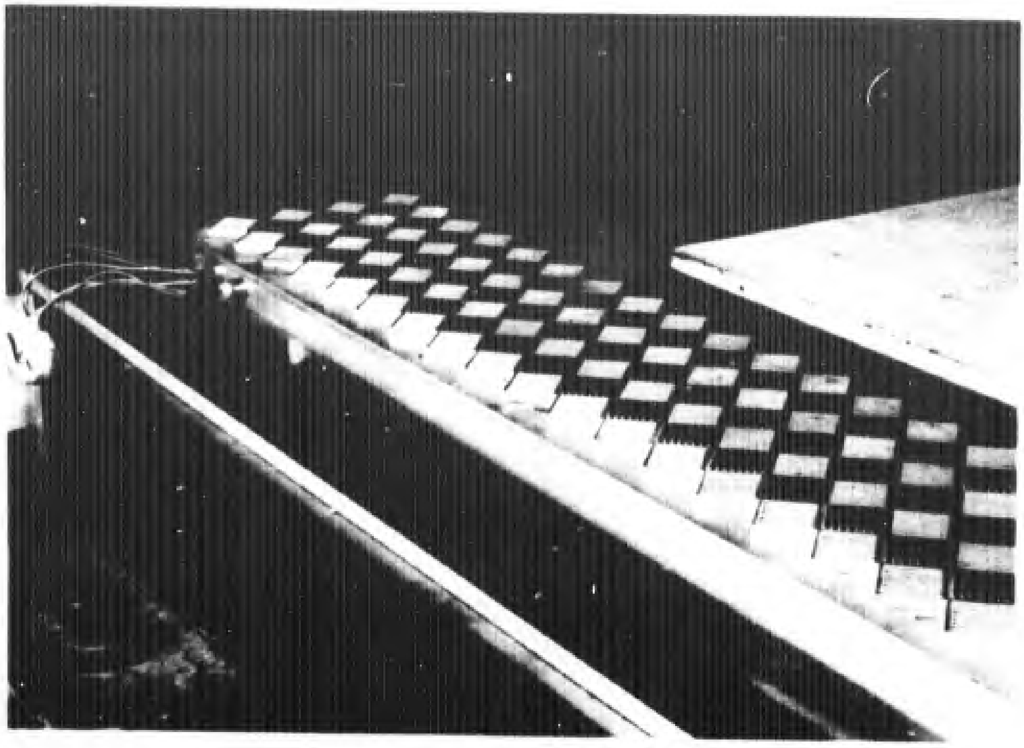

Figure 6. Cushion Forming Die Closeup
(Photo 4R11803)

Panel Roll-Up Evaluation

The narrow, full length solar cell arrays used for the vibration test program were used to evaluate the roll-up characteristics of the panels. The purpose of the tests was to determine the effect of various panel tensions on the relative displacement between panels, growth in diameter, and circumference of successive layers. The tests, in general, indicate one of the panels should be slightly more than 3.5 inches longer than the other panel. SPAR Aerospace will lengthen the boom, to accommodate the differential before the engineering/qualification model of the boom actuator unit is delivered to Hughes.

Humidity and Thermal Shock Tests of 8 mil Cells

Three test samples of 8 mil solar cells with 6 mil coverglasses have been fabricated by Heliotek and subjected to temperature, humidity, and thermal shock tests. The configuration of these test samples is as follows:

Group 1 (46 cells) – fully soldered N contact, P contact and grids

Group 2 (51 cells) – fully soldered N contact, zone soldered P contact and fully soldered grid lines

Group 3 (46 cells) – fully soldered N contact, zone soldered P contact and unsoldered grids

The sequence of inspections and tests was: visual inspection, electrical test, temperature and humidity exposure, visual examination, electrical test, thermal shock exposure, electrical test, and visual inspection. In general, the Group 2 samples, the currently planned flight configuration, appear to show an insignificant degradation from the environments imposed and are the best of the three groups.

PLANS FOR NEXT QUARTER

1) Completion of bearing and negator high/low temperature tests
2) Completion of assembly procedures for qualification model
3) Continuation of qualification model fabrication
4) Start of cell qualification test program at Heliotek

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SECTION V

ORIENTATION MECHANISM

SUMMARY

Drafting effort is within a percent or so of completion. Revised bearing characteristics were tabulated. Stress and thermal analysis is tapering off with the drafting effort. A rudimentary but useful analog system-interaction simulation was demonstrated, and momentum reaction wheel requirements derived. Design of the wheel drive electronics was initiated. Purchase orders are in process for the major procured components for the qualification model. Fabrication of component parts has been initiated.

FABRICATION STATUS

Orientation mechanism components are being fabricated. Work on one-third of the mechanical components has been initiated, and work on the remaining components will be started presently. Orders are being written to procure standard components including bearings and connectors.

Orders have been placed for major purchased parts and suppliers are beginning their production effort. Included in the major items are tachometers, brushes, slip rings, and motors.

OLSCA DRIVE BEARINGS

Computed characteristics of the revised OLSCA gimbal bearings have illustrated satisfactory bearing performance over the complete design temperature range.

DESIGN REVIEW

The overall design review, held on 5 November 1969 generated four action items accepted by the program office against this subsystem:

#07-4: Review use of aluminum for collar between shaft and bearing inner race at sliding end.
Action: Collar material changed to titanium. No effect on thermal distribution. Weight penalty insignificant.

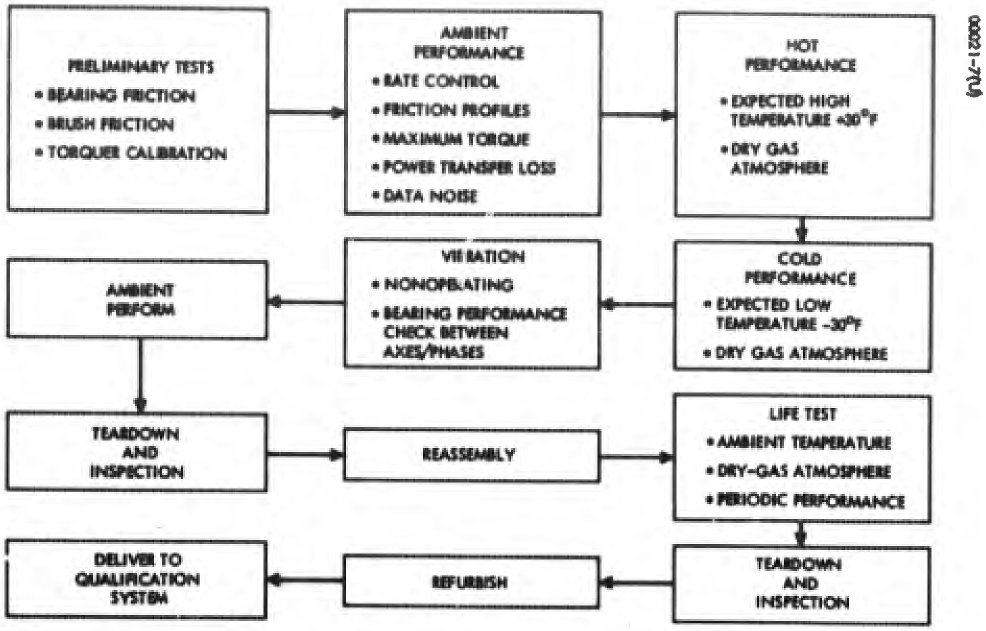


Figure 7. HS-207 OLSCA Development Test Program

#07-5: Extension arm latch design may be susceptible to inadvertent unlatching.
Action: Latch face angle reduced to 15 degrees (was 20 degrees) to reduce unlatching force component. Mating surfaces roughened to increase coefficient of friction.

#07-11: Decreased resonant frequency of longer drum-axis shaft may affect control-loop stability.
Action: Because of system nonlinearities, analysis of this problem requires reactivating the analog computer simulation. Action is, therefore, deferred pending final vehicle definition. If a problem is subsequently found to exist, shaft can be stiffened to bring frequency into an acceptable range.

#07-13: Gimbal bearing design may be critical to tolerances held over a 12-inch span.
Action: Tolerance stackups are compensated by shims. Computations indicate differential thermal expansions over the design temperature range are tolerated by the present design. Therefore, no further change is necessary.

DEVELOPMENT TEST PROGRAM

The development and life-test sequence planned for the initial unit prior to qualification with the total system is outlined in Figure 7. Note that thermal margin tests will be conducted during development, but solar-thermal-vacuum exposure will be deferred until formal qualification.

DYNAMICS AND STRESS

Dynamic loads for the updated model (52-inch "arm") have been derived. High bearing load, about 2650 pounds (3 sigma), develops on the lower support-axis bearing as a result of a resonance condition in the housing. This compares with a bearing capability of 4000 pounds. Other bearings see only about 400 pounds. Corresponding relative axial displacement of the lower bearing races is 5 mils, half attributed to flexure of the lower end plate, the remainder to the housing. It was assumed that there were no reinforcing ribs on this end plate; while probably not mandatory, Stress recommended that such ribs be added. Final bearing housing tolerances are being adjusted accordingly, and the ribs added. The above data were derived from a pseudolinear analysis, adjusted to approximate results which otherwise would be obtained from a more rigorous, costly nonlinear analysis. The analytical results are conservative and the likelihood of ever experiencing this load is extremely low.

During launch, maximum resultant load at the deployment hinge was determined to be about 630 pounds, with a 21 in-lb moment across the span

between the two bearings. Natural frequency of elbow motion in the stowed position is about 7 Hz. Titan environments do not impose a forcing function at this frequency. Agena environments, however, may include a sinusoidal input in this range, in which case it may be necessary to provide a launch lock on the support axis rotational freedom. Aerospace Corporation has the action to define the environmental test requirements for this program.

Analysis of the deployment dynamics was revised to account for the 52-inch drum-axis arm, and elimination of the deceleration spring (as had been advised at the last design review). Nominal frictional losses from all sources were assumed to be 8 in-lb, with a positive torque margin to remain at the end of the stroke. Dynamics were computed for two extremes:

1) Both springs operating, minimum friction

2) One spring broken, maximum friction

Bending moment at the weakest section of the drum-axis was constrained to be less than 2000 in-lb. It was found that a feasible spring design could be specified within this constraint.

Natural frequency of the extended and locked assembly (before panel extension) is about 5. 5 rad/sec. It was determined that the over-travel spring was inadequate for its purpose; it was eliminated in favor of a solid stop, with the deceleration energy being taken up in bending of the rather flexible deployment arm.

The new design will require careful balancing or leveling during ground tests; the former 0. 5-degree uphill-downhill tolerance is now probably excessive.

THERMAL ANALYSIS

Thermal analysis is proceeding steadily. Initial runs of the twilight orbit case (maximum solar heat input, steady state) have indicated the general approach required for thermal protection. It appears that with a bit of adjustment of details, operation in this mode within the design temperature limits and gradients can be assured. The general approach to thermal control presently involves:

1) Addition of a reflective collar around the base (interface attachment) plate of the support axis to prevent reflection of solar energy up into the lower bearing

2) General polished or VDA finish of external surfaces

3) Application of aluminized teflon to major selected areas

4) Insulation of five sides of the CEU with a thermal blanket

5) Finishing the remaining (outward-facing) side of the CEU to act as a radiator

Details of design for this orbit, setup and checkout of the noon (eclipse) orbit and the early postlaunch Agena-horizontal attitude conditions will be completed during the next quarter. Present opinion is that the eclipse orbit should not present any problems because of the relatively large mass of the mechanism and lower average heat load.

THERMAL DESIGN GROUND RULES

This section condenses all the ground rules presently being used in the FRUSA thermal analysis.

Orbital Conditions

400 n.mi. polar orbit, all conditions, twilight to noon. The preliminary orbital sequence has been outlined by Lockheed in Document #LMSC-A956857, Volume I, and is basically as follows:

1) Launch — Vehicle will fly the flightpath during this phase.

2) Orbit 1 — The flexible array drum will be erected from the stowed configuration and the OLSCA will start sun tracking. The orbit will be 400 n.mi. twilight condition and the vehicle will continue to fly the flightpath.

3) Orbits 2 through 8 — Same as Orbit 1.

4) Orbit 9 — Vehicle will be pitched nose down (OLSCA pointing toward earth). The flexible array will be extended for the first time.

5) Remainder of Mission — The vehicle will be maintained in the nose-down configuration. All orbital conditions between twilight and noon will be experienced at the 400 n.mi. altitude.

The above time sequence for the first nine orbits is inconsistent with the present FRUSA system requirements; however, changes in the time duration of each particular configuration is not expected to adversely affect the results of the thermal analysis.

Agena Boundary Conditions

Because of the lack of information concerning the interaction between the OLSCA and the vehicle, an adiabatic boundary has been assumed for both radiation and conduction. This means that there is no net heat transfer between the OLSCA and the vehicle. Definition of the basic vehicle configurations with respect to the orbit plane and the earth (provided by Lockheed in the previously referenced document) have formed the basis for estimates of

the vehicle shadowing of the OLSCA. These will be incorporated into the analysis. The assumption of thermal independence of the various FRUSA subsystems which was previously used in the solar array subsystem thermal analysis is again applied to the OLSCA.

Design Temperature Requirements

Using the above information and assumptions a thermal design is being formulated which will provide control within a total temperature excursion range of -50°F to +150°F for all OLSCA components (this includes all components in the "T" housing, the CEU, and the arm and deployment hinge mechanism) during all nominal modes. The modes are defined by the previously mentioned power dissipation document and by the LMSC outlined orbital parameters. This means that, for a particular piece of hardware, an assumed orbital configuration, and the corresponding power dissipation, the item should be capable of surviving and/or operating at all temperatures between and including -50 and +150°F. In addition to this requirement, a temperature differential of not more than 25°F will be maintained between the inner and outer races of the bearings, the rotor and stator portions of the motors, and the rotor and stator portions of the tachometers during all modes.

Failure Mode Analysis

Once the above design has been accomplished, one failure mode will be examined — this is the stall configuration for the motor. The purpose will be to make an estimate of the amount of time the winding will survive dissipating the peak power.

CONTROL SYSTEM

Momentum Cancellation Study

During this quarter, activity was devoted to refining the analog simulation circuitry by running preliminary data and looking for inconsistencies. Scaling and ideal-disturbance inputs were set up for an orbit with 45 degrees sun aspect angle and an Agena control deadband of ±4 degrees. Data were taken in the form of orbital-period time histories, and phase-plane plots of vehicle angular rate versus attitude. Disturbances other than those caused by array steering and asymmetry were not incorporated. Problems were started with zero attitude error, but with rates about all three axes approximating those produced by 1 minimum-impulse bit from the gas jets.

The following conditions for the basic study of Agena perturbations under gas-system control were run:

Deadband, degrees	Sun Aspect Angle, S', degrees 0	45	72
±4	x	x	x
±1		x	x

Results appear reasonable and consistent with theoretical predictions, so they should furnish a basis for extrapolation to other orbit conditions. Development of a basic tool for evaluation of FRUSA steering effect on Agena attitude control performance has been successfully demonstrated. A more thorough analog simulation study program is recommended, comprising the following steps:

1) Add a model of the specified momentum wheel to the simulation and repeat the basic run schedule to gather comparative data.

2) Add solar torques, aero-torques, magnetic torques, and gravity-gradient torques to the simulation, and perform check runs.

3) Add control-moment-gyro models to the simulation, in the arrangements considered by Lockheed for an Agena spacecraft, so that system behavior can be checked in the proposed long-life, pneumatics-off, mission phase.

4) Integrate the above Agena simulation with the basic OLSCA simulation to incorporate real, rather than ideal, array steering control reactions.

It should be noted that, in parallel with the analog simulation development, an improved digital simulation program has been undertaken on separate, internal, funding. This program is designed to circumvent the problems encountered in the original attempt at system digital simulation. Presuming the present program is successfully set up and checked out, it would then be available for effective use on this project. This possibility, however, is about 2 months away.

Analog Simulation of FRUSA/Agena Vehicle Interactions

An analog computer simulation of certain aspects of the FRUSA-Agena mission has been successfully mechanized. The present simulation shows attitude excursions and attitude control gas consumed in steady-state tracking mode as functions of sun angle and Agena deadband width. Ideal OLSCA control is assumed and results agree favorably with theoretical calculations.

The successful analog simulation of the Agena bang-bang control system creates the opportunity to study many other aspects of the mission such as initial acquisition, effects of environmental disturbances, and

other control system configurations, but present budgetary restraints prevent such analyses. It should be noted that this simulation provides a means of checking on, or adding to, interaction studies to be performed by the vehicle integrating contractor.

Reaction Wheel and Motor Requirements for FRUSA

Discussion

The effect of including a reaction wheel for the purpose of partially canceling angular momentum caused by OLSCA motions about the support axis were previously examined. The results have shown that a considerable saving in reaction jet control fuel is accomplished when the sun angle is high (S' > 53 degrees). The control law proposed is $J_w \Omega_w = I_{yp} \dot{\psi}$, where

J_w = moment of inertia of the wheel

I_{yp} = moment of inertia of the paddle about its y-axis

Ω_w = commanded wheel speed

$\dot{\psi}$ = angular rate of paddle about axis

The requirements for a reaction wheel and motor for the FRUSA application are examined here. It is found that for a combined wheel and motor weight of about 17 pounds, with possibly 1 pound of electronics, very satisfactory momentum storage can be achieved. Since the maximum slew rate might be changed depending on the selection of the orbital vehicle, slew rates of 1.0 deg/sec and 0.5 deg/sec, were considered. Since the paddle control motor has a torque capability of 1 ft-lb and complete momentum cancellation under all conditions would require that the reaction wheel motor have at least that much torque, the motor torque, instead, was based on the requirement that the maximum Agena position error should not exceed 5 degrees during a slew maneuver at maximum rate. The required control torque in excess of friction for a 1 deg/sec slew rate is 64 oz-in, and 21 oz-in for a slew rate of 0.5 deg/sec. The advisability of not trying to achieve total momentum cancellation under slew conditions is thus apparent.

Typical motor and wheel requirements are listed in Tables III and IV.

Concluding Remarks

By the use of a single reaction wheel about the OLSCA support axis, which will add less than 20 pounds to the vehicle weight, it is possible to reduce array steering torque reactions on the vehicle, and resulting perturbations in attitude, appreciably. Final design parameters should be verified with a coupled three-axis simulation so as to include pertinent dynamics not considered at this time. A block diagram of the reaction wheel control system is given below.

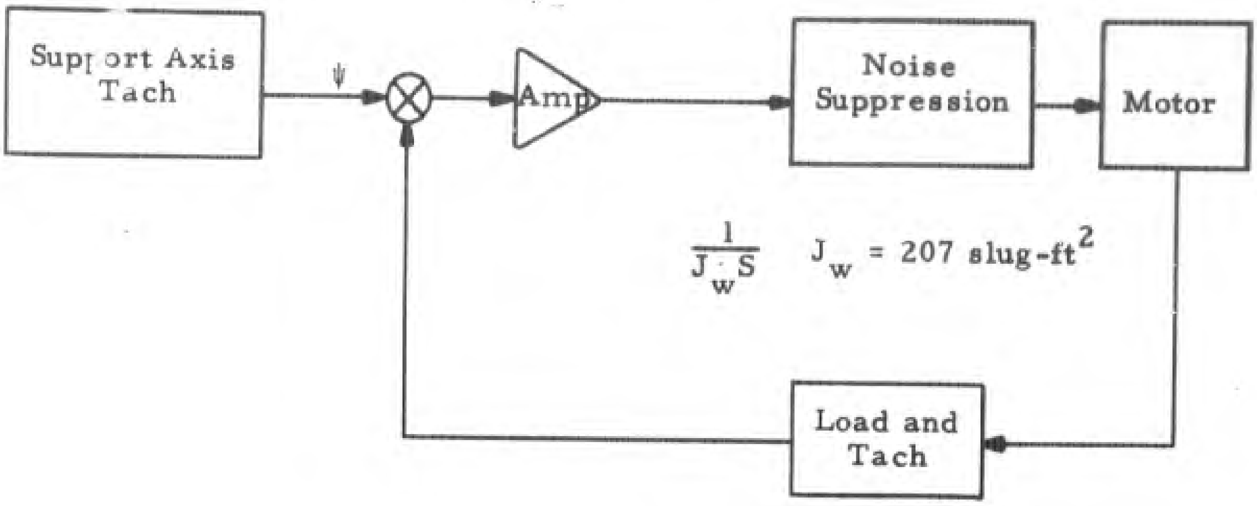


TABLE III. PRELIMINARY MOTOR REQUIREMENTS

Parameter	Slew Rate = 1 deg/sec	Slew Rate = 0.5 deg/sec
Type	2-phase induction motor	2-phase induction motor
Frequency	400 Hz	400 Hz
Volts (fixed winding)	26 volts	26 volts
Stall torque	64 oz-in	21 oz-in
Stall power	116 watts	38 watts
Synchronous speed	1200 rpm	1200 rpm
Maximum usable speed	1000 rpm	1000 rpm
Weight	5 pounds	3.5 pounds
Running power at 1000 rpm	To be determined	To be determined
Friction at 1000 rpm	To be determined	To be determined

NOTE: Design of the rate-controlled motor drive electronics has been initiated on the basis of these preliminary data.

TABLE IV. PRELIMINARY WHEEL REQUIREMENTS

Parameter	Slew Rate = 1 deg/sec	Slew Rate = 0.5 deg/sec
Momentum storage	3.6 ft-lb-sec	1.8 ft-lb-sec
Moment of inertia	0.035 slug-ft^2	0.018 slug-ft^2
Outside diameter	12 inches	10 inches
Total weight	17 pounds	12 pounds

Directed Changes

Circuit changes have been incorporated to reduce array maximum rates to 0.5 deg/sec in conformance with a Lockheed/SESP request and AFAPL directive.

As noted above, the similarly directed drum-axis extension of 1 foot has been incorporated in the design and the effect on stress levels and deployment dynamics evaluated. Although no problem is anticipated, an increase in support-axis inertia of nearly 70 percent and a reduction of drum axis fundamental bending frequency to below 1 Hz, indicate that the prudent course will require another look at the interacting dynamics of array flexibility and linkage controls.

CONTROL ELECTRONICS UNIT

Design of the CEU has been completed during this period. The CEU is defined by 32 prints and 6 design and acceptance specifications. All 38 documents have been released.

There was one principal functional change implemented since the previous report. Circuit changes have been incorporated to reduce array maximum rates to 0.5 deg/sec in conformance with a Lockheed/SESP request and AFAPL directive. The revised mechanization diagram illustrates the CEU configuration with this feature included (see Figure 8).

The CEU has seven printed circuit cards of five different types. The cards will be the conventional epoxy glass board with etched circuitry on both sides with an integral heat sink on the components side (see Figure 9). In addition to the integral heat sink, three of the cards will have an additional heat sink on the upper portion of the card to aid in the heat dissipation of the high power components (see Figure 10).

The seven printed circuit assemblies will be contained in a dip-brazed aluminum housing along with the commutator, three relays, two large capacitors, two inductors, and a terminal board assembly. Included in the design are interference isolation and proper thermal finishes to maintain unit temperature within the desired range (see Figure 11).

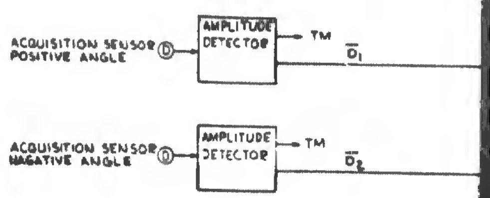
SWITCH FUNCTIONS AND LOGIC

NO.	AXIS	FUNCTION	POS LOGIC CONDTN TO OPEN	POS LOGIC CONDTN TO CLOSE
1D	DRUM	STEERING LOOP SHORT	T	$\bar{T}$
2D	DRUM	STEERING LIMIT OVERRIDE	C_L	$\bar{C}_L$
3D	DRUM	POS RATE BIAS	AB_1B_3	$\bar{A}+\bar{B}+\bar{B}_3$
4D	DRUM	RATE LOOP ACQ	A	$\bar{A}$
5D	DRUM	RATE LOOP TRACK	T	$\bar{T}$
6D	DRUM	NEG RATE BIAS	AB_2B_3	$\bar{A}+\bar{B}_2+\bar{B}_3$
1S	SUPPORT	STEERING LIMIT SHORT	T	$\bar{T}$
2S	SUPPORT	STEERING LIMIT OVERRIDE	C_L	$\bar{C}_L$
3S	SUPPORT	POS RATE BIAS	AB_4	$\bar{A}+\bar{B}_4$
4S	SUPPORT	RATE LOOP ACQ	A	$\bar{A}$
5S	DRUM	RATE LOOP TRACK	T	$\bar{T}$

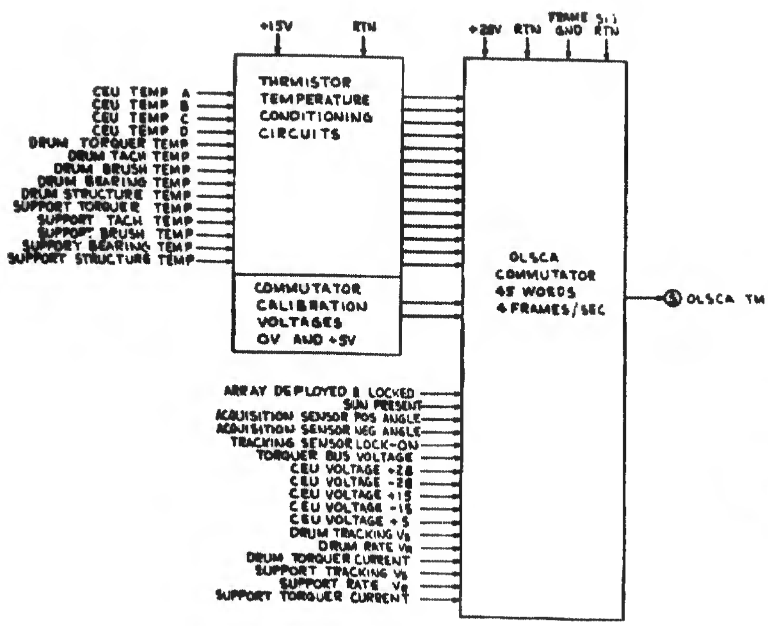
NOTE: ALTHOUGH THE SYSTEM IS DEFINED IN POSITIVE LOGIC TERMS, THE ELECTRONIC SWITCHES ACTUALLY REQUIRE THE COMPLEMENT, i.e. SWITCHES OPEN FOR LOGICAL "0" AND CLOSE FOR LOGICAL "1".

LOGIC DEFINITIONS

L LOCK-ON CELL ILLUMINATED
L_C LOCK-ON CELL BACK-UP COMMAND-ON
$T=L+L_C$ TRACKING MODE
$A=\bar{T}$ ACQUISITION MODE
D_1 POSITIVE ANGLE ACQUISITION SENSOR ILLUM
D_2 NEGATIVE ANGLE ACQUISITION SENSOR ILLUM
B_1 POSITIVE ANGLE ACQUISITION
B_2 NEGATIVE ANGLE ACQUISITION
B_3 DRUM AXIS ENABLE
B_4 SUPPORT AXIS ENABLE
C_L COMMAND LIMIT OVERRIDE-ON



TELEMETRY



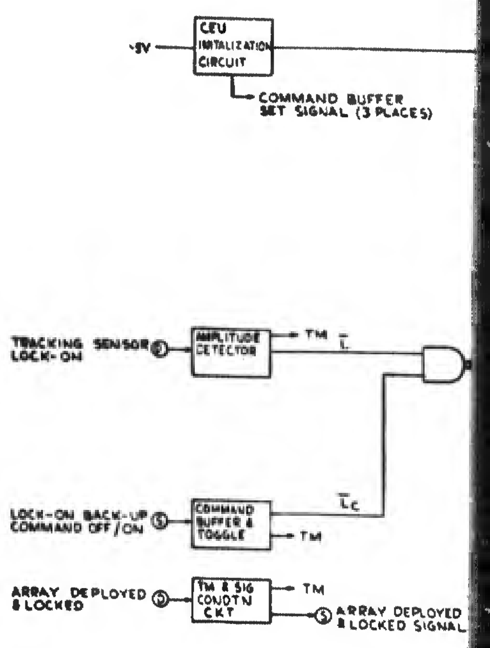
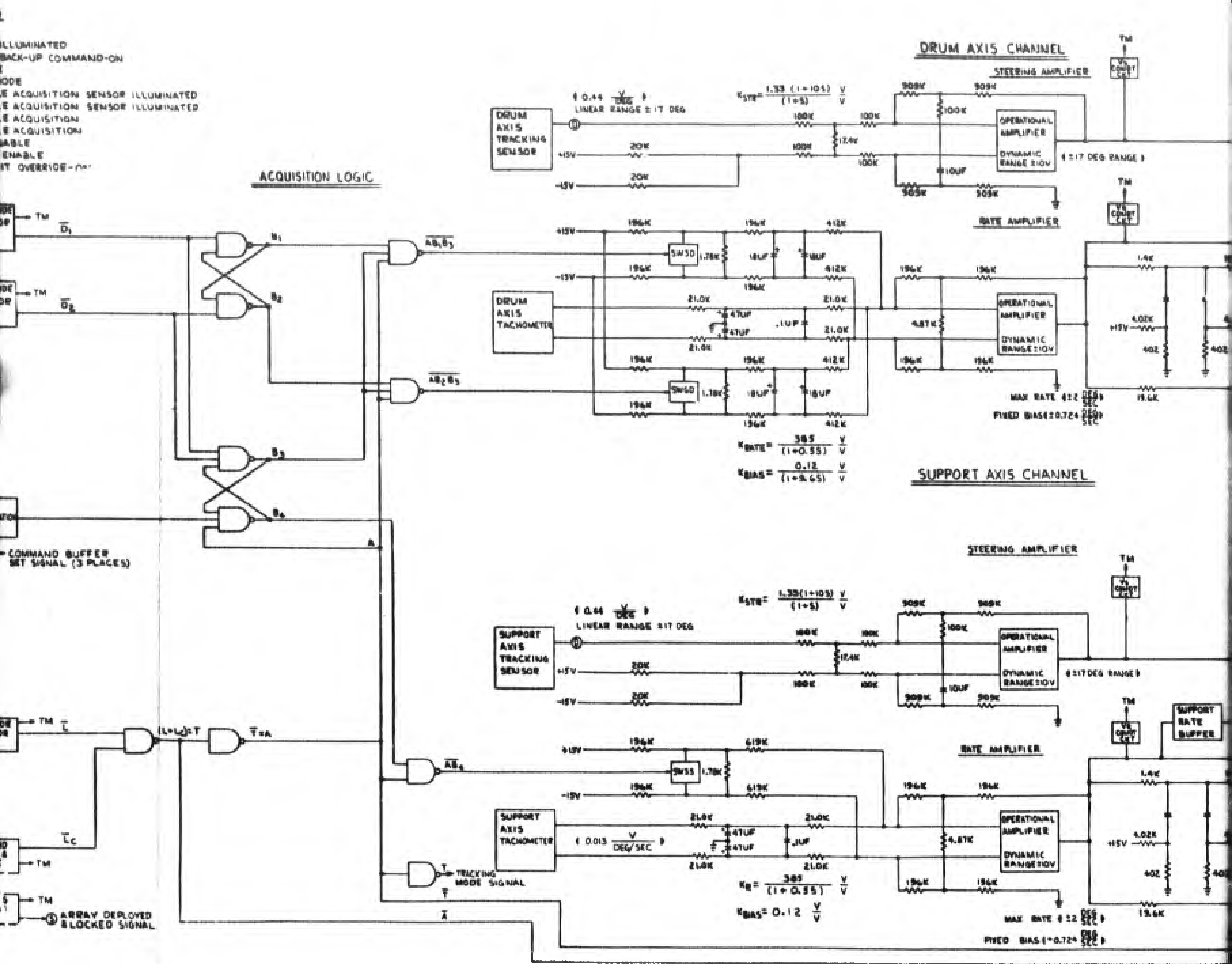
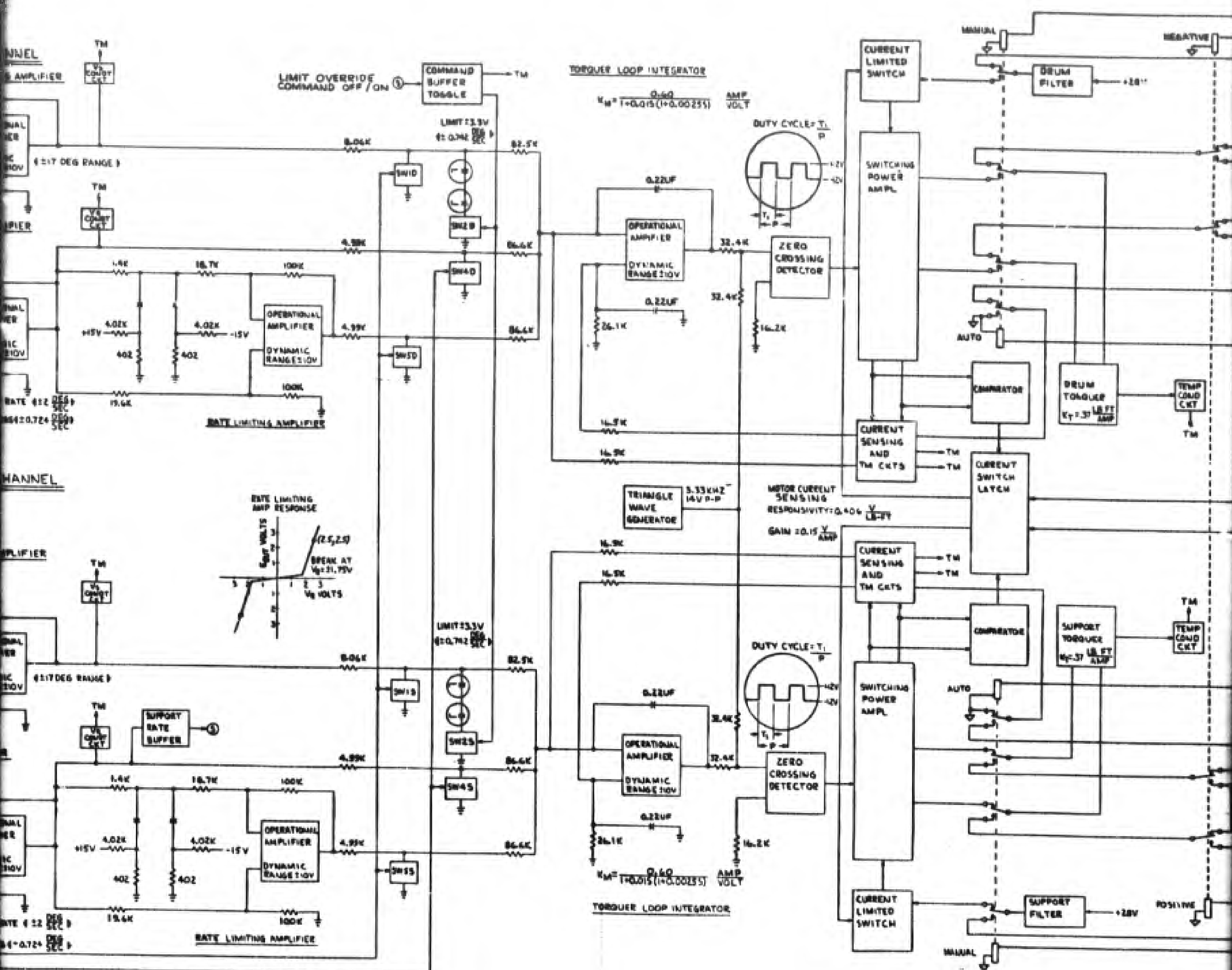


Figure 8. Control Electronics Unit Mechanization Diagram

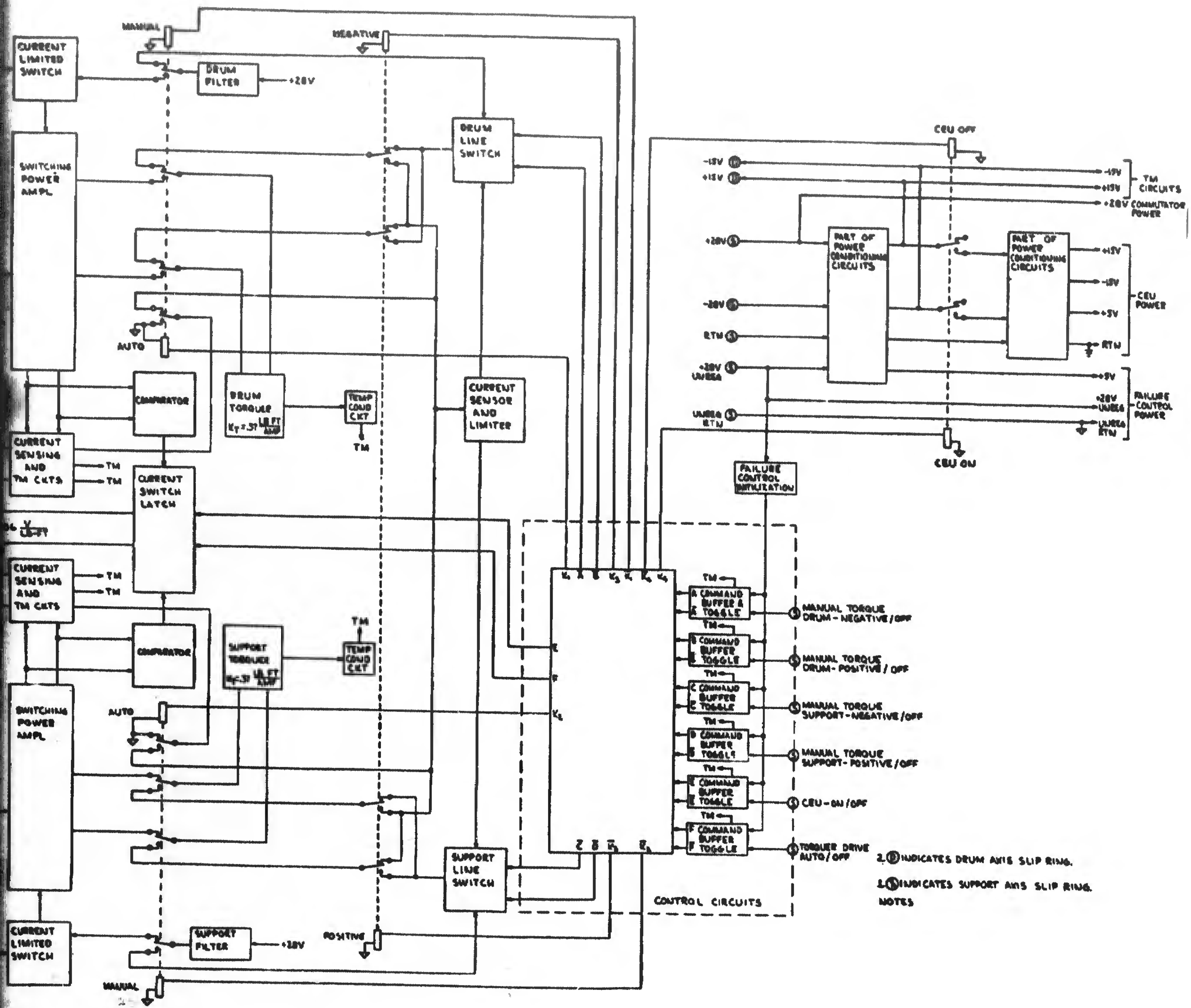


ILLUMINATED
BACK-UP COMMAND-ON
E ACQUISITION SENSOR ILLUMINATED
E ACQUISITION SENSOR ILLUMINATED
E ACQUISITION
E ACQUISITION
ENABLE
ACQUISITION LOGIC
DRUM AXIS CHANNEL
STEERING AMPLIFIER
DRUM AXIS TRACKING SENSOR
LINEAR RANGE ±17 DEG
OPERATIONAL AMPLIFIER
DYNAMIC RANGE ±10V
(±17 DEG RANGE)
RATE AMPLIFIER
DRUM AXIS TACHOMETER
MAX RATE (±2 DEG/SEC)
FIXED BIAS ±0.724 DEG/SEC
SUPPORT AXIS CHANNEL
SUPPORT AXIS TRACKING SENSOR
SUPPORT AXIS TACHOMETER
SUPPORT RATE BUFFER
COMMAND BUFFER SET SIGNAL (3 PLACES)
TRACKING MODE SIGNAL
ARRAY DEPLOYED & LOCKED SIGNAL

B


LIMIT OVERRIDE COMMAND OFF / ON
COMMAND BUFFER TOGGLE
TORQUER LOOP INTEGRATOR
DUTY CYCLE = T1/P
OPERATIONAL AMPLIFIER
DYNAMIC RANGE ±10V
ZERO CROSSING DETECTOR
CURRENT LIMITED SWITCH
SWITCHING POWER AMPL
DRUM FILTER
DRUM TORQUER
COMPARATOR
CURRENT SENSING AND TM CKTS
CURRENT SWITCH LATCH
TRIANGLE WAVE GENERATOR
RATE LIMITING AMPLIFIER
RATE LIMITING AMP RESPONSE
SUPPORT RATE BUFFER
SUPPORT TORQUER
SUPPORT FILTER
TEMP COND CKT
MANUAL
AUTO
NEGATIVE
POSITIVE

C


CURRENT LIMITED SWITCH
MANUAL
NEGATIVE
DRUM FILTER
+28V
DRUM LINE SWITCH
SWITCHING POWER AMPL
CEU OFF
TM CIRCUITS
COMMUTATOR POWER
PART OF POWER CONDITIONING CIRCUITS
CEU POWER
AUTO
COMPARATOR
DRUM TORQUER
TEMP COND CKT
TM
CURRENT SENSOR AND LIMITER
FAILURE CONTROL POWER
CEU ON
FAILURE CONTROL INITIALIZATION
CURRENT SENSING AND TM CKTS
CURRENT SWITCH LATCH
SUPPORT TORQUER
COMMAND BUFFER & TOGGLE
COMMAND BUFFER TOGGLE
MANUAL TORQUE DRUM - NEGATIVE/OFF
MANUAL TORQUE DRUM - POSITIVE / OFF
MANUAL TORQUE SUPPORT - NEGATIVE/OFF
MANUAL TORQUE SUPPORT - POSITIVE/OFF
CEU - ON/OFF
TORQUER DRIVE AUTO/OFF
INDICATES DRUM AXIS SLIP RING.
INDICATES SUPPORT AXIS SLIP RING.
NOTES
SUPPORT LINE SWITCH
CONTROL CIRCUITS
SUPPORT FILTER
POSITIVE

D

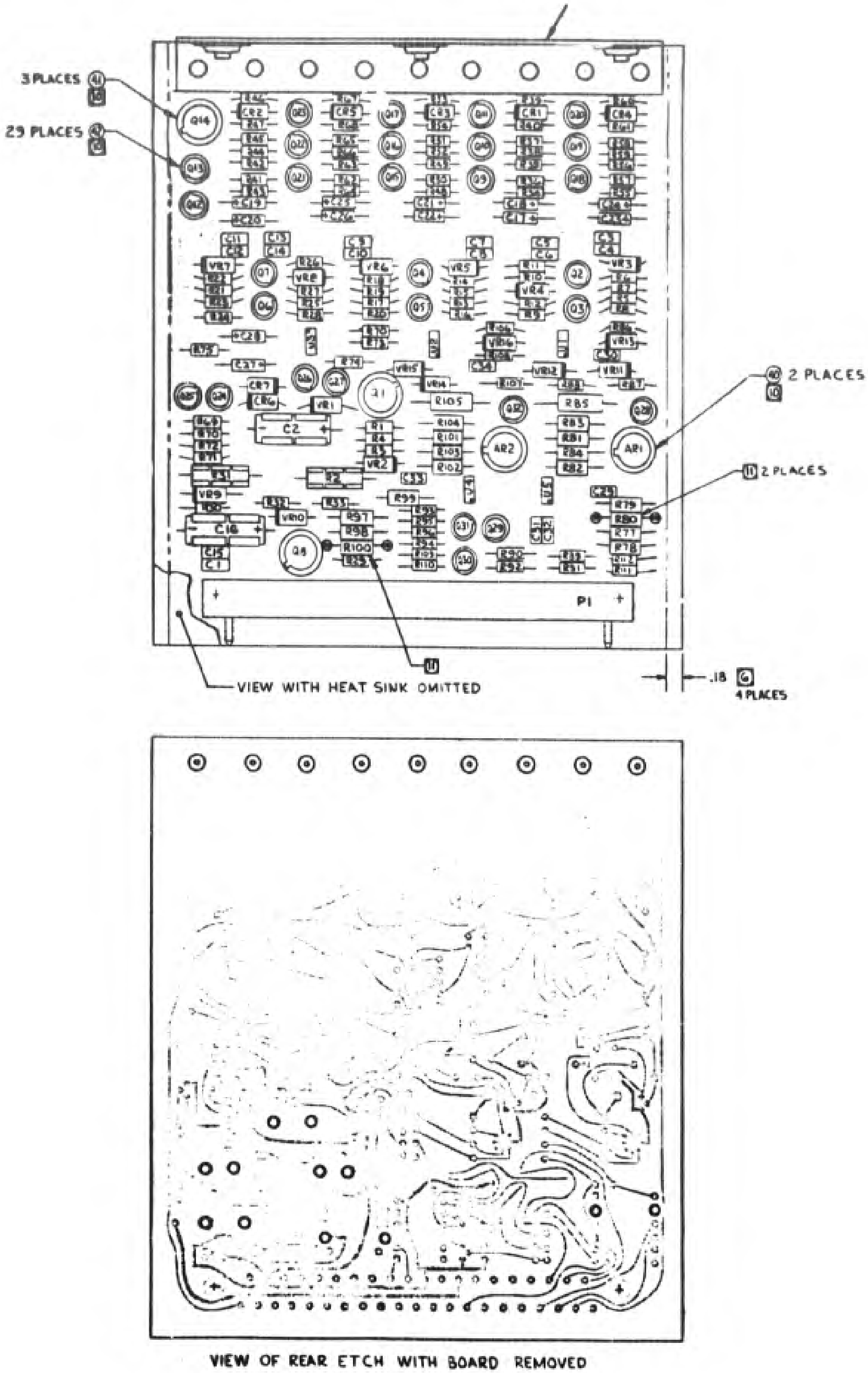
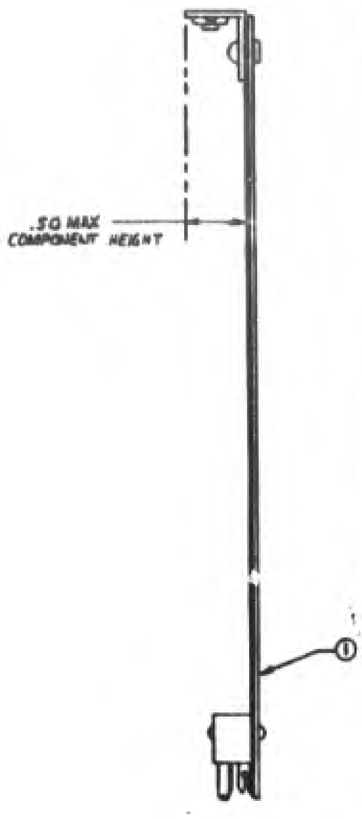


Figure 9. Failure Control Circuit Card Assembly

A



COMPONENT IDENTIFICATION													
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R2	39	R34	26	R66	29	R98	25	C2	17	C34	16	Q9	14
R3	21	R35	26	R67	27	R99	34	C3	16			Q10	13
R4	20	R36	26	R68	30	R100	35	C4	18			Q11	14
R5	22	R37	28	R69	26	R101	36	C5	16	U1	3	Q12	14
R6	23	R38	29	R70	32	R102	33	C6	18	U2	3	Q13	13
R7	24	R39	27	R71	20	R103	35	C7	16	U3	3	Q14	15
R8	25	R40	30	R72	25	R104	36	C8	18	U4	4	Q15	14
R9	22	R41	26	R73	26	R105	37	C9	16	U5	5	Q16	13
R10	23	R42	26	R74	32	R106	38	C10	18	VR1	6	Q17	14
R11	24	R43	26	R75	20	R107	25	C11	16	VR2	7	Q18	14
R12	25	R44	31	R76	25	R108	22	C12	18	VR3	8	Q19	13
R13	22	R45	29	R77	33	R109	25	C13	16	VR4	8	Q20	14
R14	23	R46	27	R78	33	R110	25	C14	18	VR5	8	Q21	14
R15	24	R47	20	R79	34	R111	25	C15	16	VR6	8	Q22	13
R16	23	R48	26	R80	35	R112	25	C16	17	VR7	8	Q23	14
R17	22	R49	26	R81	36			C17	19	VR8	8	Q24	14
R18	23	R50	26	R82	33			C18	19	VR9	6	Q25	13
R19	24	R51	28	R83	36			C19	19	VR10	7	Q26	14
R20	25	R52	29	R84	33			C20	19	VR11	9	Q27	13
R21	22	R53	27	R85	37	CR1	11	C21	19	VR12	9	Q28	13
R22	23	R54	30	R86	38	CR2	11	C22	19	VR13	10	Q29	13
R23	24	R55	26	R87	25	CR3	11	C23	19	VR14	9	Q30	14
R24	25	R56	26	R88	22	CR4	11	C24	19	VR15	9	Q31	13
R25	22	R57	26	R89	27	CR5	11	C25	19	VR16	10	Q32	13
R26	23	R58	28	R90	27	CR6	11	C26	19	Q1	12		
R27	24	R59	29	R91	27	CR7	11	C27	19	Q2	13		
R28	25	R60	27	R92	27			C28	19	Q3	13		
R29	25	R61	30	R93	22			C29	16	Q4	13		
R30	20	R62	26	R94	21	AR1	2	C30	6	Q5	13		
R31	39	R63	26	R95	27	AR2	2	C31	16	Q6	13		
R32	21	R64	26	R96	22			C32	16	Q7	13		

SELECTED PARTS CHART 8	
ITEM NO.	SELECT FROM
35	RNR55C20R0FS, 40R2FS, 60R4FS 80R6FS, 1000FS, 1210FS
34	RNR55C5621FS, 5761FS, 5901FS, 6041FS

11 RESISTOR MOUNTED TIGHT AGAINST HEATSINK.

10 TO BE MOUNTED FLUSH AND DRAWN TIGHT AGAINST THE BOARD BEFORE SOLDERING.

9. COMPONENT PARTS TO BE SELECTED FROM THE FOLLOWING:
RNR TYPE FROM MIL-R-55182
RWR TYPE FROM MIL-R-39007
RCR TYPE FROM MIL-R-39008
CSR TYPE FROM MIL-C-39003
CKR TYPE FROM MIL-C-39014
TX TYPE FROM MIL-S-19500

8 TO BE SELECTED AT TEST, PER DS30829-002

7 MARK PER HP8-29, CL2, WHITE

6 CONFORMAL COAT PER HP 16-66, TYPE I, CL 2, EXCEPT DELETE TEST SPECIMEN, AND SUBSTITUTE 4.0 GRAMS MAX OF CAB-O-SIL FOR QTY REQD IN PARA 3.4.2 TABLE I MASK CONNECTOR PINS, TOP FLANGE OF STIFFENER AND EDGES OF BOARD PER DIMENSION SHOWN

5. TEST PER DS30829-002

4. PARTIAL REF DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION PREFIX WITH UNIT NO. OR SUBASSY DESIGNATION(S)

3 VENDOR ITEM - SEE SPEC CONTROL DWG

2. ASSEMBLE PER HP31-8, TYPE I

1. FOR SCHEMATIC DIAGRAM SEE 3064232

NOTES: UNLESS OTHERWISE SPECIFIED

B

ATION

ITEM	REF	ITEM	REF	ITEM
16	C33	16	Q8	12
17	C34	16	Q9	14
16			Q10	13
18			Q11	14
16	U1	3	Q12	14
18	U2	3	Q13	13
16	U3	3	Q14	15
18	U4	4	Q15	14
16	U5	5	Q16	13
18	VR1	6	Q17	14
16	VR2	7	Q18	14
18	VR3	8	Q19	13
16	VR4	8	Q20	14
18	VR5	8	Q21	14
16	VR6	8	Q22	13
17	VR7	8	Q23	14
19	VR8	8	Q24	14
19	VR9	6	Q25	13
19	VR10	7	Q26	14
19	VR11	9	Q27	13
19	VR12	9	Q28	13
19	VR13	10	Q29	13
19	VR14	9	Q30	14
19	VR15	9	Q31	13
19	VR16	10	Q32	13
19	Q1	12		
19	Q2	13		
19	Q3	13		
16	Q4	13		
16	Q5	13		
16	Q6	13		
16	Q7	13		

SELECTED PARTS CHART 8

ITEM NO.	SELECT FROM
35	RNR55C20R0FS, 40R2FS, 60R4FS 80R6FS, 1000FS, 1210FS
34	RNR55C5621FS, 5761FS, 5901FS, 6041FS

AGAINST HEATSINK.

D DRAWN TIGHT
SOLDERING.

LECTED

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, PER DS30829-002

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6, TYPE I, CL 2,
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PREFIX WITH
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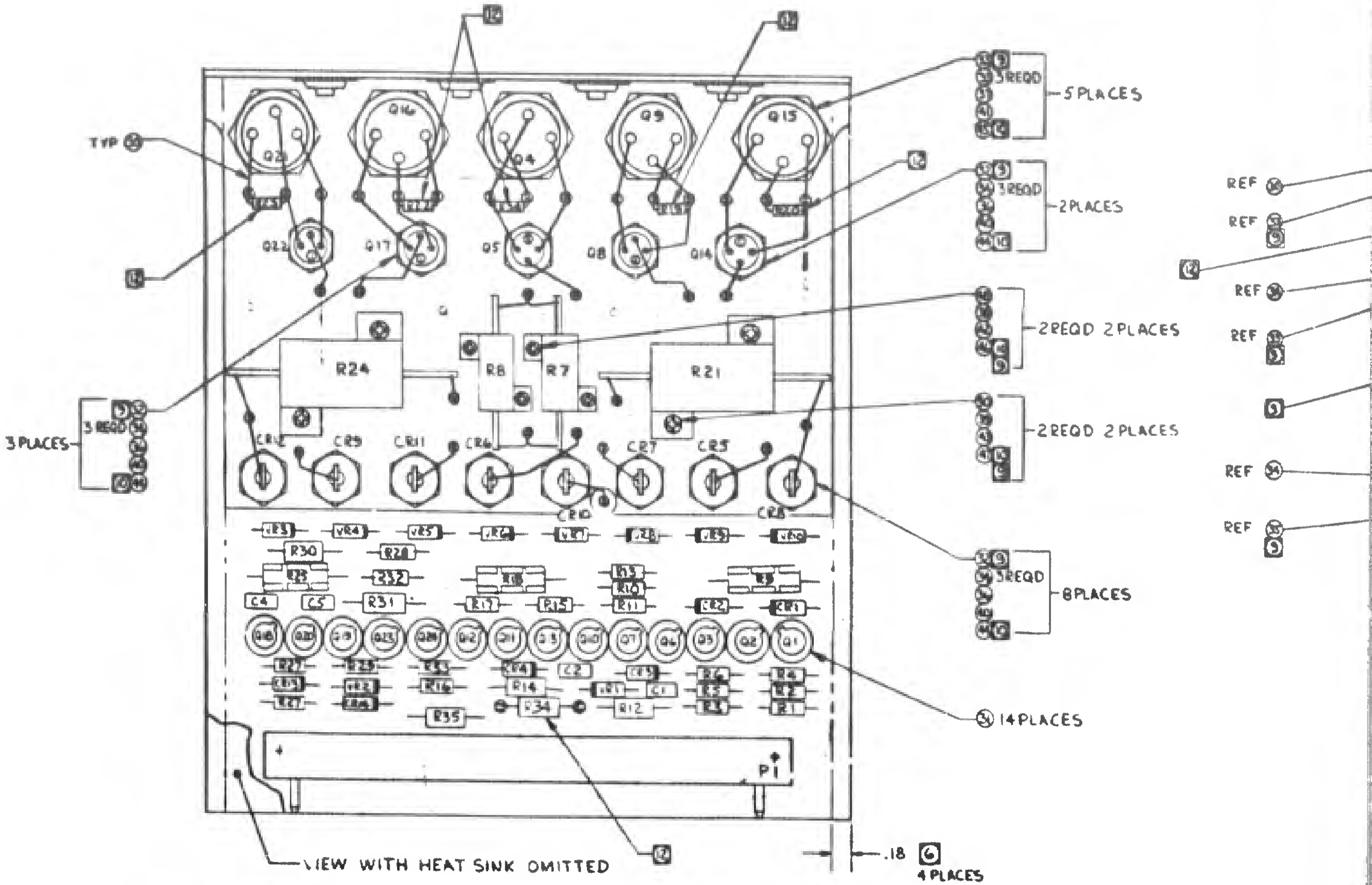
ROL DWG

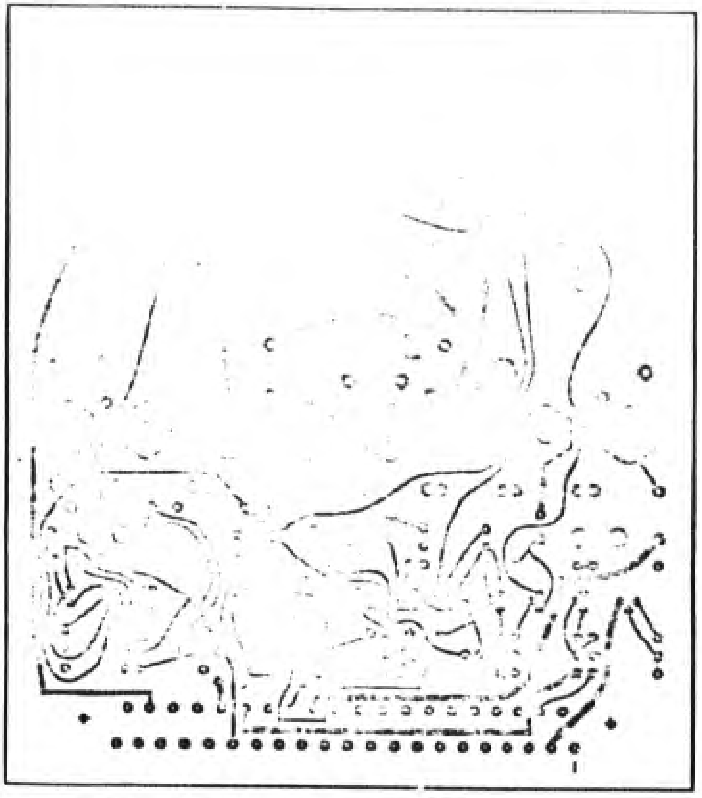
E I

EE 3064232
CIFIED

	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION		FIND NO.
	AR			SOLDER, COMP Sn60, WRAP2, QQ-S-571		43
5	29		988175-2	INSULATOR, DISK - TRANSISTOR		42
5	3		988175-5	INSULATOR, DISK - TRANSISTOR		41
5	2		988049-13	WASHER - INSULATOR		40
	2		RWR89S1000FS	RESISTOR 100Ω, ±1%, 3 W		39
	8		RCR07G392JS	RESISTOR 3.9K, ±5%, 1/4 W		38
	2		RCR32G510JS	510Ω, ±5%, 1W		37
	4		RNR55C1582FS	15.8K, ±1%, 1/10W		36
6	2		SEE CHART	±1%, 1/10W		35
8	2		SEE CHART	±1%, 1/10W		34
	6		RNR55C1002FS	10K, ±1%, 1/10W		33
	2		RCR07G153JS	15K, ±5%, 1/4 W		32
	1		RCR07G332JS	3.3K, ±5%, 1/4 W		31
	4		RCR07G182JS	1.8K, ±5%, 1/4 W		30
	5		RCR07G512JS	5.1K, ±5%, 1/4 W		29
	4		RCR07G472JS	4.7K, ±5%, 1/4 W		28
	10		RCR07G243JS	24K, ±5%, 1/4W		27
	17		RCR07G333JS	33K, ±5%, 1/4W		26
	17		RCR07G103JS	10K, ±5%, 1/4W		25
	6		RCR07G752JS	7.5K, ±5%, 1/4W		24
	6		RCR07G303JS	30K, ±5%, 1/4W		23
	10		RCR07G622JS	6.2K, ±5%, 1/4W		22
	3		RCR07G203JS	20K, ±5%, 1/4W		21
	7		RCR07G102JS	RESISTOR 1K, ±5%, 1/4W		20
	12		M39003/1-3076	CAPACITOR, 1UF ±10%, 50V		19
	6		M39014/2-0145	CAPACITOR, .047UF, ±10%, 100V		18
	3		M39003/1-3094	CAPACITOR, 10UF, ±10%, 50V		17
	14		M39014/2-0350	CAPACITOR, .1UF ±10%, 100V		16
4	1		908836-1	TRANSISTOR		15
	12		TX2N2907A	TRANSISTOR		14
	17		TX2N3700	TRANSISTOR		13
	2		TX2N3019	TRANSISTOR		12
	7		TX1N3070	DIODE		11
	2		TX1N754A	DIODE, ZENER		10
	4		TX1N962B	DIODE, ZENER		9
3	6		908706-15	DIODE, ZENER		8
3	2		908706-13	DIODE, ZENER		7
3	2		908708-9	DIODE, ZENER		6
4	1		908906-1	INTEGRATED CIRCUIT		5
3	1		908901-1	INTEGRATED CIRCUIT		4
3	3		908929-1	INTEGRATED CIRCUIT		3
3	2		908916-1	AMPLIFIER		2
	1		3064233	PRINTED WIRING BOARD	7E	1

C

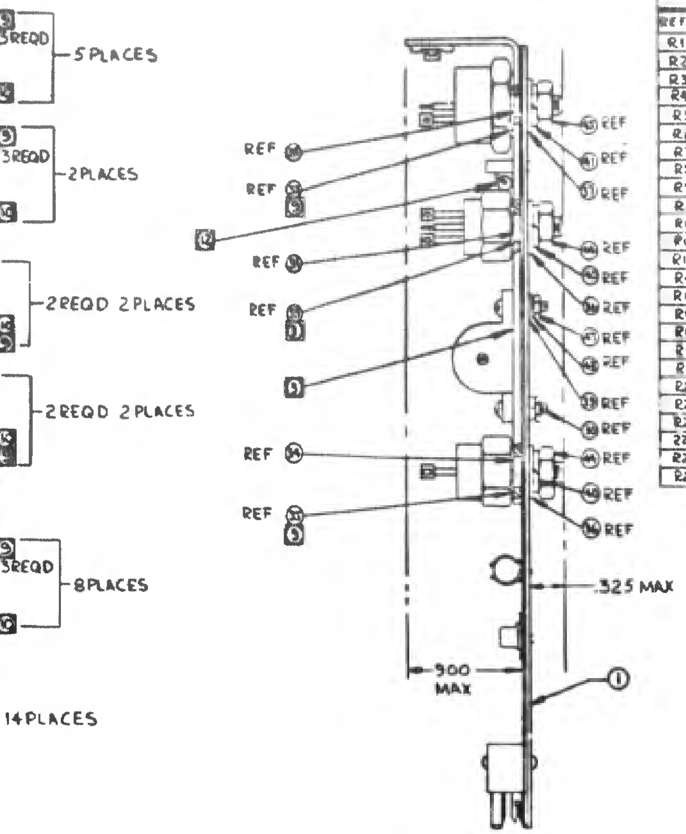




VIEW OF REAR ETCH WITH BOARD REMOVED

Figure 10. Torquer Drive Circuit Card Assembly

A



COMPONENT IDENTIFICATION

REF	ITEM	REF	ITEM	REF	ITEM	REF	ITEM	REF	ITEM	REF	ITEM	REF	ITEM
R1	16	R26	21	C1	14	CR1	11	VR1	3	Q1	10		
R2	17	R27	24	C2	14	CR2	11	VR2	3	Q2	9		
R3	17	R28	21	C3	15	CR3	12	VR3	4	Q3	10		
R4	16	R29	22	C4	14	CR4	12	VR4	4	Q4	5		
R5	17	R30	23	C5	14	CR5	13	VR5	4	Q5	6		
R6	18	R31	25			CR6	13	VR6	4	Q6	10		
R7	19	R32	21			CR7	13	VR7	4	Q7	10		
R8	19	R33	21			CR8	13	VR8	4	Q8	6		
R9	20	R34	30			CR9	13	VR9	4	Q9	5		
R10	21	R35	29			CR10	3	VR10	4	Q10	7		
R11	22	R36	2			CR11	13			Q11	9		
R12	23					CR12	13			Q12	9		
R13	21					CR13	12			Q13	9		
R14	25					CR24	12			Q14	8		
R15	24									Q15	5		
R16	16									Q16	5		
R17	21									Q17	6		
R18	26									Q18	10		
R19	27									Q19	10		
R20	27									Q20	7		
R21	28									Q21	5		
R22	27									Q22	8		
R23	27									Q23	9		
R24	28									Q24	7		
R25	26												

12 RESISTOR MOUNTED TIGHT AGAINST HEATSINK.

11 TO BE MOUNTED FLUSH AND DRAWN TIGHT AGAINST THE BOARD BEFORE SOLDERING.

10 TORQUE REQUIREMENTS
- #2 = 2 INLB
- #4 = 5 INLB
- #10 = 20 TO 25 INLB
- #1/4 = 50 TO 70 INLB

9 APPLY ITEM 49 BOTH SIDES OF WASHER AND/OR BOTTOM OF COMPONENT.

8. COMPONENT PARTS TO BE SELECTED FROM THE FOLLOWING:
RER TYPE FROM MIL-R-39009
RNR TYPE FROM MIL-R-55182
RCR TYPE FROM MIL-R-39008
RWR TYPE FROM MIL-R-39007
CKR TYPE FROM MIL-C-39014
TX TYPE FROM MIL-S-19500

7 MARK PER HP8-29, CL2, WHITE

6 CONFORMAL COAT PER HP 16-66, TYPE I, CL 2, EXCEPT DELETE TEST SPECIMEN, AND SUBSTITUTE 4.0 GRAMS MAX OF CAB-O-SIL FOR QTY REQD IN PARA 3.4.2 TABLE I MASK CONNECTOR PINS, TOP FLANGE OF STIFFENER AND EDGES OF BOARD PER DIMENSION SHOWN

5. TEST PER DS 30829-004

4. PARTIAL REF DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION PREFIX WITH UNIT NO. OR SUBASSY DESIGNATION(S)

3 VENDOR ITEM - SEE SPEC CONTROL DWG

2. ASSEMBLE PER HP31-8, TYPE I

1. FOR SCHEMATIC DIAGRAM SEE 3064229

NOTES: UNLESS OTHERWISE SPECIFIED

A/R			SOLDER,
A/R			WIRE,
A/R			COMPO
QTY REQD	CODE IDENT	PART NO OR IDENTIFYING NO	

B

ON

REF	ITEM	REF	ITEM
Q1	10		
Q2	9		
Q3	10		
Q4	8		
Q5	6		
Q6	10		
Q7	10		
Q8	6		
Q9	8		
Q10	7		
Q11	[illegible]		
Q12	9		
Q13	9		
Q14	8		
Q15	8		
Q16	5		
Q17	6		
Q18	10		
Q19	10		
Q20	7		
Q21	5		
Q22	8		
Q23	9		
Q24	7		

AINST HEATSINK.

RAWN TIGHT
RE SOLDERING.

F WASHER
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182
008
007
014
500

,TYPE I,CL 2,
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F CAB-O-SIL
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F BOARD

E SHOWN;
PREFIX WITH
TION(S)

OOL DWG

E I

E 3064229

CIFIED

QTY REQD	CODE IDENT	PART NO OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	ZONE	FIND NO
A/R			SOLDER, COMP SN60, WRAP 2, QQ-S-571		51
A/R			WIRE, SOLID COND, HMS2-1132-223 TYPE I		50
A/R			COMPOUND, HEATSINK, GREASE HMS20-1565		43

PARTS LIST

	QTY REQD	CODE IDENT	PART NO OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	ZONE	FIND NO
	4		NAS1101-2	SCREW (#2-56)		48
	4		NAS671C4	NUT (#4-40)		47
	4		NAS671C2	NUT (#2-56)		46
3	5		988022-4	NUT (#1/4-28)		45
	13		NAS671C10	NUT (#10-32)		44
	4		NAS620C4L	WASHER, LOCK (#4)		43
	4		NAS620C2L	WASHER, LOCK (#2)		42
	5		MS35338-139	WASHER, LOCK (1/4)		41
	13		MS35338-138	WASHER LOCK (#10)		40
	4		NAS660C4L	WASHER, FLAT (#4)		39
	4		NAS660C2L	WASHER, FLAT (#2)		38
	5		AN960C416L	WASHER, FLAT (1/4)		37
	13		AN960C10L	WASHER, FLAT (#10)		36
3	15		988343-2	INSULATOR, SPACER (1/4)		35
3	39		988343-1	INSULATOR, SPACER (#10)		34
3	5		988049-4	INSULATOR (1/4)		33
3	13		988049-1	INSULATOR (#10)		32
3	14		988175-1	INSULATOR (TO-18)		31
	4		NAS1101-4	SCREW (#4-40)		30
	1		RNR60E1962BS	RESISTOR 19.6K±1/10%, 1/8W		29
	2		RER70FR150S	RESISTOR .15Ω ±1%, 15W		28
	5		RCR07G101JS	RESISTOR 100Ω±5%, 1/4W		27
	2		RWR89S1001FS	RESISTOR 1K ±1%, 3W		26
	2		RCR20G123JS	RESISTOR 12K ±5%, 1/2W		25
	2		RCR07G472JS	RESISTOR 4.7K±5%, 1/4W		24
	2		RCR20G103JS	RESISTOR 10K±5%, 1/2W		23
	2		RCR07G273JS	RESISTOR 27K±5%, 1/4W		22
	7		RCR07G242JS	RESISTOR 2.4K±5%, 1/4W		21
	1		RWR89S2001FS	RESISTOR 2K±1%, 3W		20
	2		RER60F00R1S	RESISTOR .1Ω±1%, 5W		19
	1		RCR07G163JS	RESISTOR 16K±5%, 1/4W		18
	3		RCR07G243JS	RESISTOR 24K±5%, 1/4W		17
	3		RCR07G203JS	RESISTOR 20K±5%, 1/4W		16
	1		M39014/2-0340	CAPACITOR .015UF ±10%, 100V		15
	4		M39014/1-0353	CAPACITOR 560PF, ±10%, 200V		14
	8		TX1N3891	DIODE		13
	4		TX1N3070	DIODE		12
	2		TX1N3595	DIODE		11
	6		TX2N2907A	TRANSISTOR		10
	5		TX2N3700	TRANSISTOR		9
3	2		908806-1	TRANSISTOR		8
3	3		908823-1	TRANSISTOR		7
3	3		908824-1	TRANSISTOR		6
3	5		908825-1	TRANSISTOR		5
3	8		908708-8	DIODE, ZENER		4
3	2		908706-3	DIODE, ZENER		3
	1		RNR60E1002BS	RESISTOR 10K±1/10%, 1/8W		2
	1		3064230	PRINTED WIRING BOARD		1

PARTS LIST

C

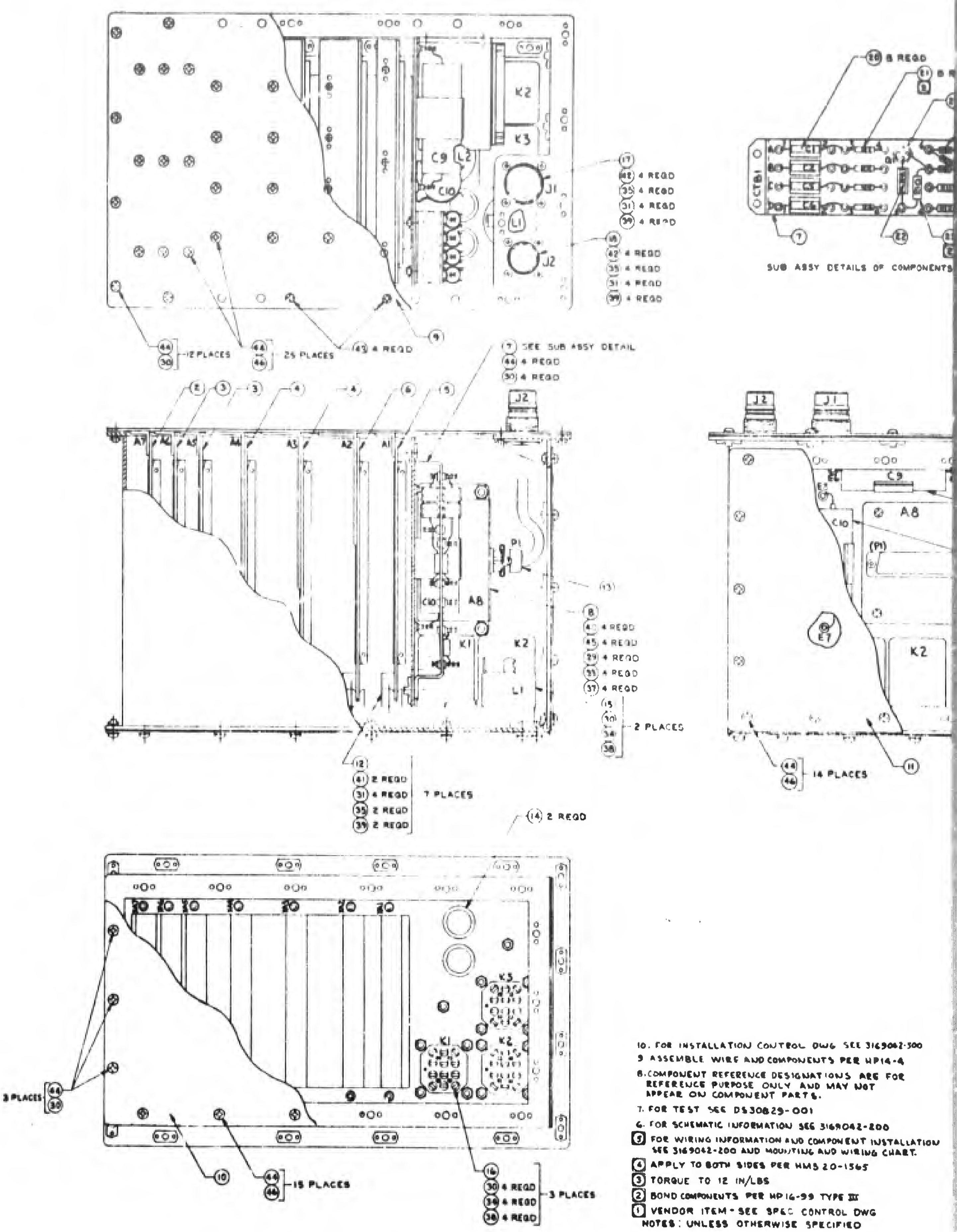
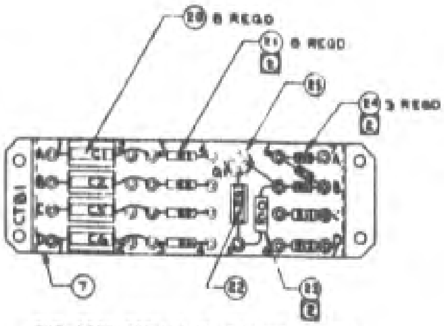


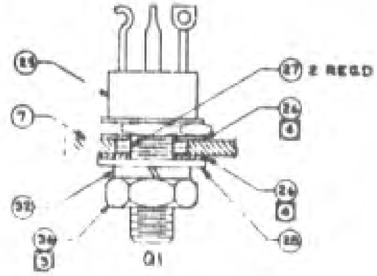
Figure 11. Control Electronics Unit Assembly

4



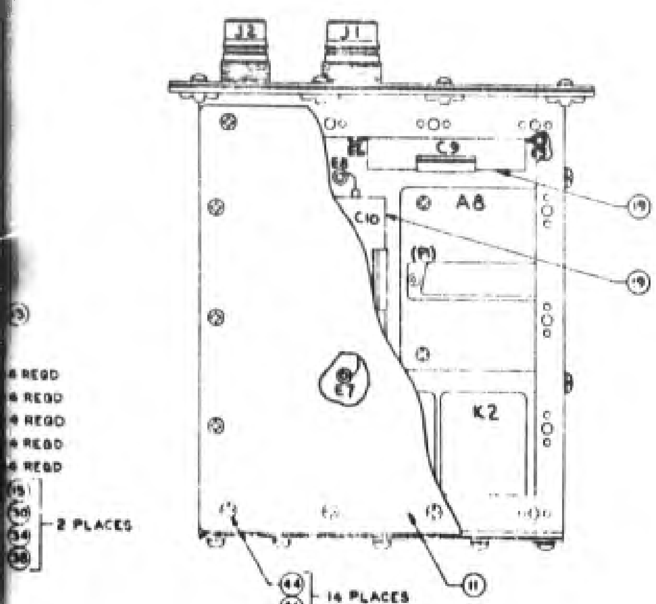
SUB ASSY DETAILS OF COMPONENTS BRKT

DETAIL



DETAIL TRANSISTOR MTG
SCALE 4:1

COMPONENT MOUNTING AND WIRING 5							
FROM	ITEM	TO	DES	FROM	ITEM	TO	DES
E1	50	E2	–	CTB1-B1	50	CTB1-D5	–
E2	50	E3	–	-BB1	49	K1-B2	–
E3	50	CTB1-D7	–	-BB2	21	CTB1-BB4	R4
E5	19	E6	C9	-B3	21	CTB1-B4	R2
E7	19	E8	C10	-BB4	50	CTB1-CC4	–
K1-X2	50	K1-Y2	–	-B6	50	Q1-B	–
K1-Y2	50	K2-X2	–	-B6	23	CTB1-D5	R10
K2-X2	50	K2-Y2	–	-B6	24	-B7	VR1
K2-Y2	50	K3-X2	–	-C1	20	-C3	C5
K3-X2	50	K3-Y2	–	-CC1	20	-CC2	C7
K3-Y2	48	CTB1-A7	–	-C1	50	CTB1-D1	–
K3-A1	50	K3-C1	–	-CC1	49	K2-B1	–
K3-C1	50	K3-D3	–	-CC2	21	CTB1-CC4	R7
K3-D3	50	K3-B3	–	-C3	21	-C4	R5
K3-A3	50	K3-B1	–	-CC4	50	-DD4	–
K3-C3	50	K3-D1	–	-C6	50	-C7	R11
L1-1	50	L2-1	–	-C6	49	-D6	–
L1-2	49	CTB1-AA1	–	-D1	20	-D3	C6
L2-2	49	CTB1-DD1	–	-DD1	20	-DD2	C8
				-DD2	21	-DD4	R8
				-D3	21	CTB1-D4	R6
				-D5	50	Q1-C	–
				-D6	52	CTB1-D7	R12
				CTB1-DD6	53	CTB1-DD7	RT1
CTB1-A1	20	CTB1-A3	C1				
-A1	50	-B1	–				
-AA1	20	-BB1	C3				
-AA2	21	-AA4	R3				
-A3	21	-A4	R1				
-AA4	50	-BB4	–				
-A6	24	-A7	VR3				
-A6	24	-B7	VR2				
-B1	20	-B3	C2				
CTB1-BB1	20	CTB1-BB2	C4				



4	AR		COMPOUND, HEATSINK, GREASE		47
	54	NAS620C6L	WASHER		46
	4	NAS620C8L	WASHER		45
	73	NAS1631C2	SCREW, TORQ SET-PAN HD		44
	4	NAS1102C06-7	SCREW, TORQ SET-FLAT HD		43
	8	MS24693C3	SCREW, FLAT HD		42
	14	NAS1635-04-12	SCREW, PAN HD		41
	4	NAS1635-08-7	SCREW, PAN HD		40
	22	NAS671C4	NUT, PLAIN HEX		39
	14	NAS671C6	NUT, PLAIN HEX		38
	4	NAS671C8	NUT, PLAIN HEX		37
	1	NAS671C10	NUT, PLAIN HEX		36
	22	MS35338-135	WASHER, LOCK		35
	14	MS35338-136	WASHER, LOCK		34
	4	MS35338-137	WASHER, LOCK		33
	1	MS35338-138	WASHER, LOCK		32
	36	NAS620A4L	WASHER, FLAT		31
	33	NAS620A6L	WASHER, FLAT		30
	4	NAS620A8L	WASHER, FLAT		29
	1	AN960C10L	WASHER, FLAT		28
1	2	988343-1	WASHER, INSULATOR		27
1	2	988049-1	WASHER, INSULATOR		26
1	1	908806-1	TRANSISTOR		25
	3	TXIN758	DIODE		24
	1	RCR32G471JS	RESISTOR		23
	1	RWR89S5001FS	RESISTOR		22
1	8	908616-1	RESISTOR		21
	6	M39006/3-1572	CAPACITOR		20
1	2	908526-34	CAPACITOR		19
	1	988592-96	CONNECTOR, RECEPTACLE		18
	1	988592-91	CONNECTOR, RECEPTACLE		17
1	3	988272-1	RELAY		16
1	2	988406-16	REACTOR POWER		15
	2	NAS557-10	GROMMET, PLASTIC-SPLIT		14
1	1	988201-15	CONNECTOR, PLUG		13
1	7	988588-1	CONNECTOR, RECEPTACLE		12
	1	3064250	PLATE, END COVER		11
	1	3064249	PLATE, BOTTOM COVER		10
	1	3064248	PLATE, TOP COVER		9
	1	3169034-100	COMMUTATOR		8
5	1	3064247	BRACKET ASSY, COMPONENTS		7
	1	3064234	CIRCUIT CARD ASSY		6
	1	3064231			5
	2	3064228			4
	2	3064225			3
	1	3064222	CIRCUIT CARD ASSY		2
	1	3064246	FRAME ASSY		1
	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

					56
					55
	AR	HMS20-1550	LACING TAPE		54
1	1	988627-2	THERMISTOR		53
	1	RLR60E1002BS	RESISTOR 10K, ±1/10%, 1/8 W		52
	1	RLR60E1962BS	RESISTOR 19.6K, ±1/10%, 1/8 W		51
	AR		WIRE, SOLID, INS HMS2-1244-18 TYPE		50
	AR	NAS1051BUC999	WIRE, STRANDED, INS AWG 18		49
	AR	NAS1032ZUC999	WIRE, STRANDED, INS AWG 22		48
	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

10. FOR INSTALLATION CONTROL DWG SEE 3169042-300
9. ASSEMBLE WIRE AND COMPONENTS PER HP14-4
8. COMPONENT REFERENCE DESIGNATIONS ARE FOR REFERENCE PURPOSE ONLY AND MAY NOT APPEAR ON COMPONENT PARTS.
7. FOR TEST SEE DS30829-001
6. FOR SCHEMATIC INFORMATION SEE 3169042-200
5 FOR WIRING INFORMATION AND COMPONENT INSTALLATION SEE 3169042-200 AND MOUNTING AND WIRING CHART.
4 APPLY TO BOTH SIDES PER HMS 20-1565
3 TORQUE TO 12 IN/LBS
2 BOND COMPONENTS PER HP16-99 TYPE III
1 VENDOR ITEM - SEE SPEC CONTROL DWG
NOTES: UNLESS OTHERWISE SPECIFIED

bly

B

Purchase orders have been placed for all electronic components and hardware. Many of the purchased parts have been received and are now in stores. The manufacturing orders for the fabricated items have been placed in the appropriate manufacturing area, with the result that all parts are in work or have been finished and placed in stores awaiting final assembly.

PLANS FOR NEXT QUARTER

1) Fabrication of the qualification mechanism and control electronics unit

2) Production of a detailed development test procedure and design and fabrication of required test features

3) Development of flight acceptance test requirements and procedures

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SECTION VI

POWER SUBSYSTEM

A design review was conducted to evaluate the circuit design of the power subsystem. Although several minor comments were offered, no changes in design resulted. With this milestone passed, product design began with the packaging of the battery charge controller. Preliminary design is now complete with detail design in progress. The conceptual design phase for the power conditioning unit has begun. Packaging of the load bank will start at the completion of the design of the two electronics packages. Breadboard subsystem testing has been delayed as a result of minor problems with transistor current unbalance in the ±28 volt inverter. A solution to this problem has been found and, after the required modifications are made, the planned subsystem thermal tests will be conducted.

The simplified block diagram (Figure 12) has been changed to show the battery charge controllers as separate units. They are individually packaged using the battery/charge control assembly plate as an integral part of the electronics package. The addition of two commands to separately turn on or off each charge provides more flexibility and increases the chances of survival for restricted operation if one of the batteries fails. A change in the overtemperature circuit and the addition of two commands for enabling or disabling the circuit provide a temperature-voltage hysteresis loop. When battery temperature reaches 120°F, the charge current is automatically cut off. When the temperature drops below 120°F and the battery cell voltage drops to 1.28 volts, charging is resumed.

BATTERY/CHARGE CONTROLLER TEST PROGRAM

A test setup including a battery of 24-6 A-H cells and the breadboard charge control electronics was assembled and 20 simulated orbits were run. A 99 minute orbit was simulated, including 57 minutes of discharge at 0.8 ampere. The initial charge current of 1.0 ampere was employed. The charge current automatically reduced to 0.6 ampere when sufficient recharge was obtained. Temperature during the test varied from 32° to 110°F. Preliminary analysis indicates that the system operated satisfactorily, although the number of orbits was insufficient for fully stable conditions to be obtained. Additional orbiting will be run when certain test equipment problems are resolved.

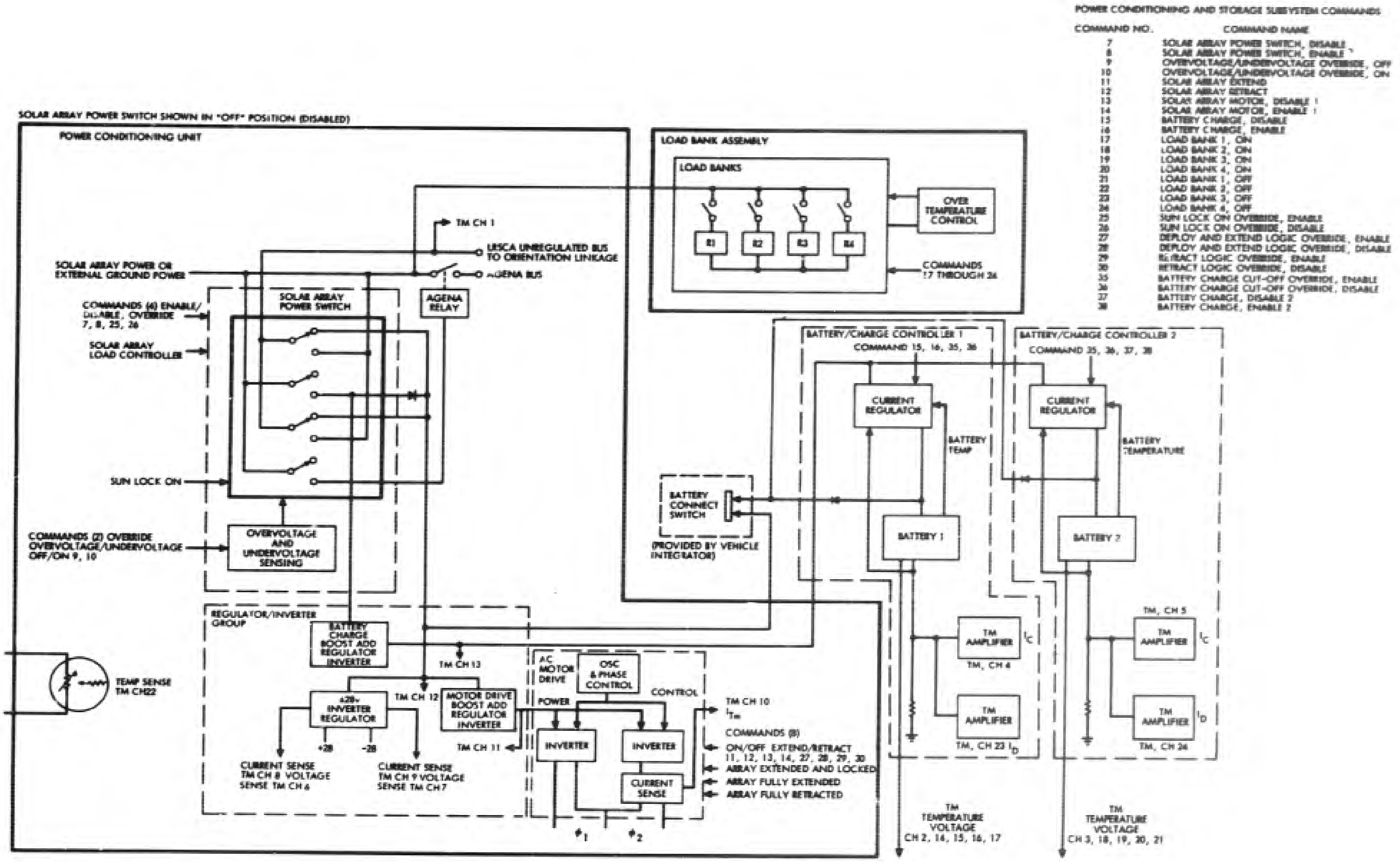


Figure 12. Power Conditioning and Storage Subsystem Functional Block Diagram

SECTION VII

INSTRUMENTATION SUBSYSTEM

NEW PCM TELEMETRY CONFIGURATION

The FRUSA telemetry subsystem has been modified to incorporate a PCM/FM/FM telemetry link. This is a change from the previously considered PAM/FM/FM system and will increase the overall link accuracy and will circumvent difficulties in the processing of real-time flight data.

Figure 13 shows, in functional block diagram format, the proposed configuration. Teledyne Model 306 PAM commutators are being modified to allow word synchronization with the Agena PCM processor commutator index pulse. The pulse rate of this signal must be two times the Agena main frame rate or 250 pps. This signal is divided by a factor of 2 in the commutator to establish a sample rate of 125 samples per second. Each commutator word, therefore, will be sampled 125/45 = 2-7/8 samples per second. Accelerometer and strain gage data are supercommutated at 3 times per FRUSA frame to provide 3 x 125/45 = 8-1/3 samples per second.

A frame reset capability is also being provided in the FRUSA commutators to allow frame synchronization of all three commutators. This will greatly simplify the Agena PCM processor design by eliminating the need for generating an individual frame synchronization pulse for each FRUSA commutator. It will also simplify ground station data processing. Both of these synchronization signals will be applied to the FRUSA commutators through the orientation mechanism slip rings.

TELEMETRY LISTS

A number of telemetry measurements have been rearranged to new commutator word positions to simplify harness design and minimize sensor/commutator wire lengths. Tables V through VIII list all current telemetry measurements.

INSTRUMENTATION CONDITIONING UNIT

Product design of the instrumentation conditioning unit (ICU) has been completed. All parts are on order and fabrication has been started.

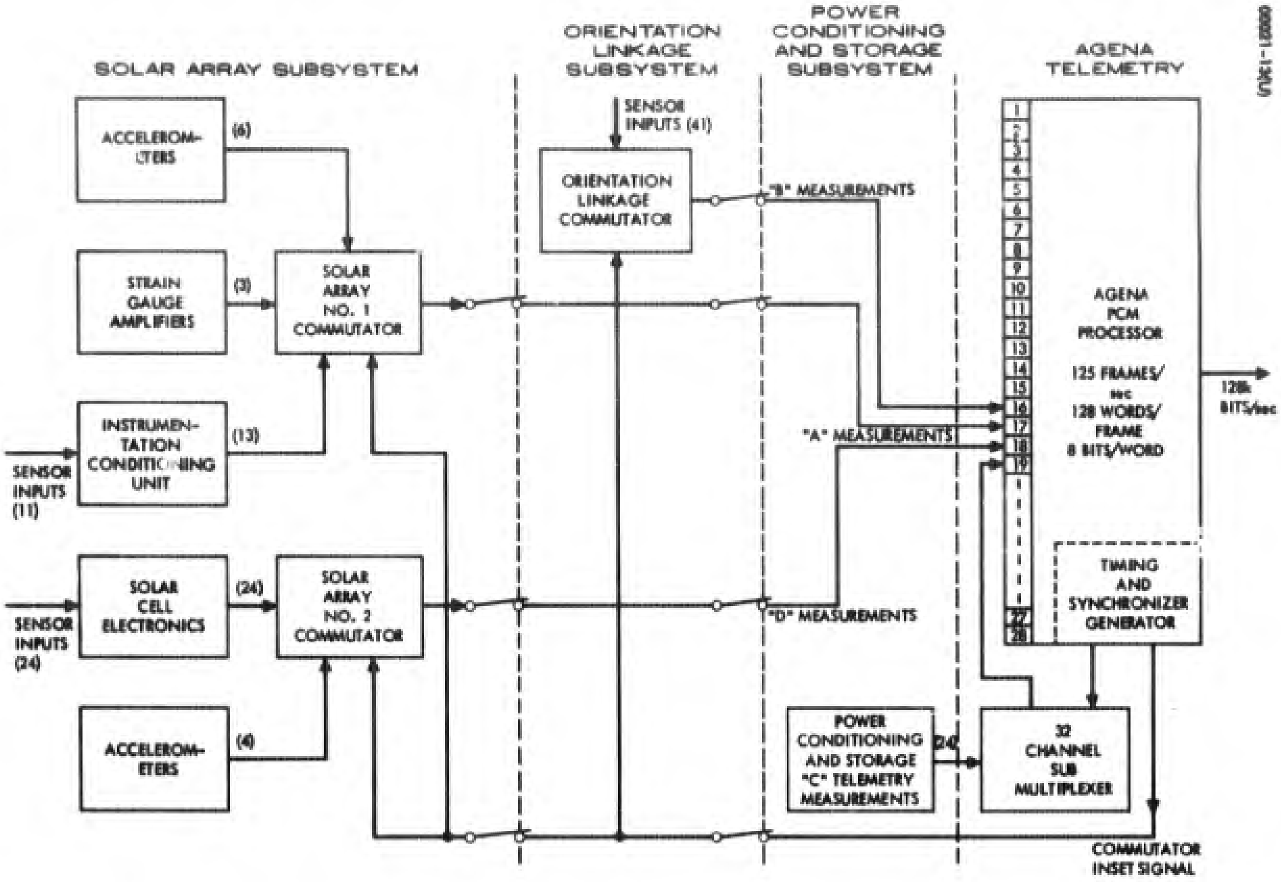


Figure 13. FRUSA/Agena Telemetry System

TABLE V. SOLAR ARRAY COMMUTATOR NO. 1 TELEMETRY MEASUREMENTS

Data Channel	Function
A-1	Zero calibration
A-2	Full-scale calibration
A-3	STEM tip inboard accelerometer (V axis), panel 1
A-4	STEM tip outboard accelerometer (W axis), panel 1
A-5	STEM tip inboard accelerometer (V axis), panel 2
A-6	STEM tip inboard accelerometer (U axis), panel 2
A-7	STEM tip outboard accelerometer (W axis), panel 2
A-8	Boom length compensator strain gage, panel 1
A-9	STEM strain gage
A-10	Drum mechanism inboard accelerometer (V axis)
A-11	Boom length compensator strain gage, panel 2
A-12	Array position indicator (pulse count)
A-13	Spreader bar 1 temperature
A-14	Solar array fully extended
A-15	Solar array fully retracted
A-16	Spreader bar 2 temperature
A-17	Drum bearing temperature
A-18	STEM tip inboard accelerometer (V axis), panel 1
A-19	STEM tip outboard accelerometer (W axis), panel 1
A-20	STEM tip inboard accelerometer (V axis), panel 2
A-21	STEM tip inboard accelerometer (U axis), panel 2
A-22	STEM tip outboard accelerometer (W axis), panel 2

Table V (continued)

Data Channel	Function
A-23	Boom length compensator strain gage, panel 1
A-24	STEM strain gage
A-25	Drum mechanism inboard accelerometer (V axis)
A-26	Boom length compensator strain gage, panel 2
A-27	Solar array subassembly released
A-28	Solar array motor temperature
A-29	Spare
A-30	Solar array voltage
A-31	Spare
A-32	Spare
A-33	STEM tip inboard accelerometer (V axis), panel 1
A-34	STEM tip outboard accelerometer (W axis), panel 1
A-35	STEM tip inboard accelerometer (U axis), panel 2
A-36	STEM tip inboard accelerometer (U axis), panel 2
A-37	STEM tip outboard accelerometer (W axis), panel 2
A-38	Boom length compensator strain gage, panel 1
A-39	STEM strain gage
A-40	Drum mechanism inboard accelerometer (V axis)
A-41	Boom length compensator strain gage, panel 2
A-42	Solar array No. 2 current
A-43	Solar array No. 1 current
A-44	Synchronization
A-45	Synchronization

TABLE VI. ORIENTATION LINKAGE COMMUTATOR TELEMETRY MEASUREMENTS

Data Channel	Function
B-1	Zero calibration
B-2	Full-scale calibration
B-3	Spare
B-4	Acquisition sensor, positive
B-5	Acquisition sensor, negative
B-6	Tracking sensor, lockon cell
B-7	Tracking sensor, drum axis error
B-8	Tracking sensor, support axis error
B-9	Sun sensor excitation, +15 volts dc
B-10	Sun sensor excitation, -15 volts dc
B-11	Drum axis torquer current (high level)
B-12	Support axis torquer current (high level)
B-13	Control electronics unit, +5 volts dc
B-14	Control electronics unit, +28 volts dc
B-15	Control electronics unit, -28 volts dc
B-16	Solar array subassembly deployed and locked
B-17	Drum axis tachometer voltage
B-18	Support axis tacometer voltage
B-19	Drum axis torquer temperature
B-20	Support axis torquer temperature
B-21	Drum axis shaft temperature at bearing
B-22	Drum axis housing temperature at bearing, 2 o'clock

Table VI (continued)

Data Channel	Function
B-23	Control electronics unit temperature A
B-24	Control electronics unit temperature B
B-25	Support axis shaft temperature at bearing
B-26	Support axis housing temperature at bearing, 2 o'clock
B-27	Drum axis housing temperature at bearing, 6 o'clock
B-28	Drum axis brush temperature
B-29	Drum axis housing temperature at bearing, 10 o'clock
B-30	Support axis housing temperature at bearing, 6 o'clock
B-31	Support axis brush temperature
B-32	Support axis housing temperature at bearing, 10 o'clock
B-33	Torquer voltage
B-34	Drum axis torquer current (low level)
B-35	Support axis torquor current (low level)
B-36	Manual torque drum axis negative
B-37	Manual torque drum axis positive
B-38	Manual torque support axis negative
B-39	Manual torque support axis positive
B-40	Auto torquer drive
B-41	Manual sun lockon
B-42	Limit override
B-43	Spare
B-44	Synchronization
B-45	Synchronization

TABLE VII. POWER CONDITIONING UNIT TELEMETRY MEASUREMENTS

Data Channel	Function
C-1	FRUSA unregulated voltage
C-2	Battery 1 voltage
C-3	Battery 2 voltage
C-4	Battery 1 charge current
C-5	Battery 2 charge current
C-6	Regulated voltage (+28 volts)
C-7	Regulated voltage (-28 volts)
C-8	Regulated current (+28 volts)
C-9	Regulated current (-28 volts)
C-10	Solar array motor current
C-11	Motor drive regulator output voltage
C-12	±28 volt regulator input voltage
C-13	Battery charge regulator output voltage
C-14	Battery 1A temperature
C-15	Battery 1B temperature
C-16	Battery 1C temperature
C-17	Battery 1D temperature
C-18	Battery 2A temperature
C-19	Battery 2B temperature
C-20	Battery 2C temperature
C-21	Battery 2D temperature
C-22	Power conditioning unit temperature
C-23	Battery 1 discharge current
C-24	Battery 2 discharge current
C-25	Spare
C-26	Spare
C-27	Spare

TABLE VIII. SOLAR ARRAY COMMUTATOR NO. 2
TELEMETRY MEASUREMENTS

Data Channel	Function
D-1	Zero calibration
D-2	Full-scale calibration
D-3	Mid-scale calibration
D-4	Drum mechanism outboard accelerometer (V axis)
D-5	Drum mechanism outboard accelerometer (W axis)
D-6	STEM tip outboard accelerometer (V axis), panel 2
D-7	STEM tip outboard accelerometer (V axis), panel 1
D-8	Spare
D-9	Spare
D-10	Cell/module selection bit 1
D-11	Cell/module selection bit 2
D-12	Cell/module selection bit 3
D-13	Cell/module selection bit 4
D-14	Array panel 1 temperature, root outboard
D-15	Load condition bit 1
D-16	Load condition bit 2
D-17	Load condition bit 3
D-18	Array panel 1 temperature, midpoint inboard
D-19	Drum mechanism outboard accelerometer (V axis)
D-20	Drum mechanism outboard accelerometer (W axis)
D-21	STEM tip outboard accelerometer (V axis), panel 2
D-22	STEM tip outboard accelerometer (V axis), panel 1
D-23	Spare

Table VIII (continued)

Data Channel	Function
D-24	Spare
D-25	Solar cell electronics temperature
D-26	Array panel 1 temperature, root, inboard
D-27	Array panel 1 temperature, midpoint, outboard
D-28	Array panel 1 temperature, outer sector, outboard
D-29	Array panel 2 temperature, root, outboard
D-30	Array panel 2 temperature, midpoint, inboard
D-31	Array panel 2 temperature, outer sector, inboard
D-32	Cell/module voltage
D-33	Cell/module current
D-34	Drum mechanism outboard accelerometer (V axis)
D-35	Drum mechanism outboard accelerometer (W axis)
D-36	STEM tip outboard accelerometer (V axis), panel 2
D-37	STEM tip outboard accelerometer (V axis), panel 1
D-38	Spare
D-39	Spare
D-40	Solar cell electronics, power
D-41	Array panel 2 temperature, root, inboard
D-42	Array panel 2 temperature, midpoint, outboard
D-43	Spare
D-44	Synchronization
D-45	Synchronization

SOLAR CELL ELECTRONICS UNIT

A mechanization (functional block diagram) of the solar cell electronics unit (SCEU) is shown in Figure 14. A modified four wire system is used to interconnect the cells and modules with their associated SCEU input voltage and current measurement circuits. This eliminates harness drop errors in measuring cell-module voltages.

An analysis was conducted to determine the optimum load values for the reference cells and modules. The three resistance load values that are used allows seven load combinations plus open circuit voltage to be obtained. The lowest value or "short circuit" current measurement is obtained when all load values are switched out, leaving only the 0.25 ohm current sensing resistor and the interconnecting harness resistance. The latter values plus the relay contact resistances limit the minimum load value that can be applied (1.5 ohms when the panel is 200°F).

Figures 3 and 4 graphically summarize the result of the analysis. The load values selected will provide measurements of all significant V-I points on the curve for the range of temperatures that will be encountered in orbit.

Product design of the SCEU is approximately 75 percent complete. To simplify interfaces, Solar Array Commutator No. 2 is being packaged inside the SCEU.

WORK TO BE PERFORMED

1) Complete product design for SCEU

2) Place orders for commutators, strain gage amplifiers, and accelerometers

3) Continue fabrication of ICU and SCEV

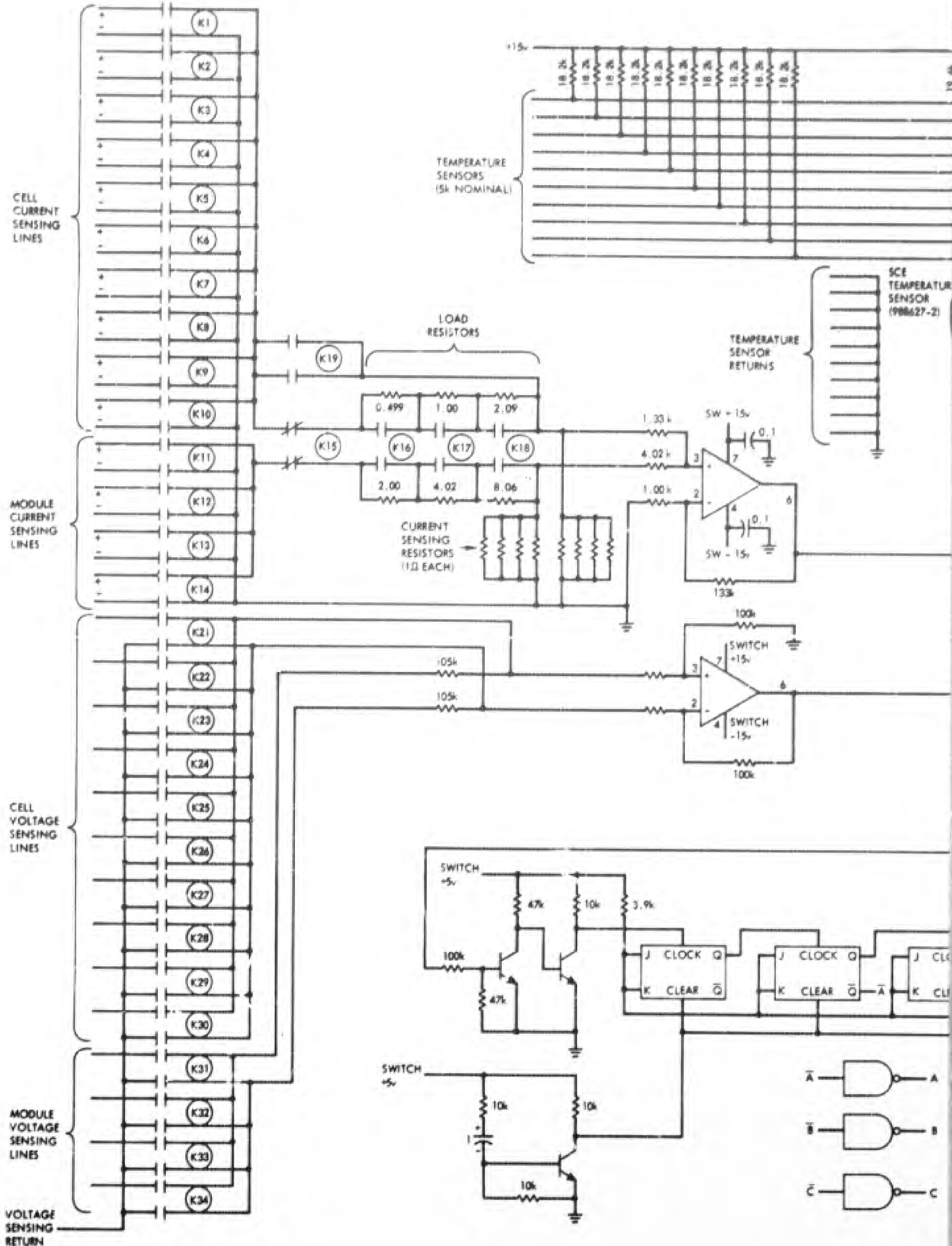
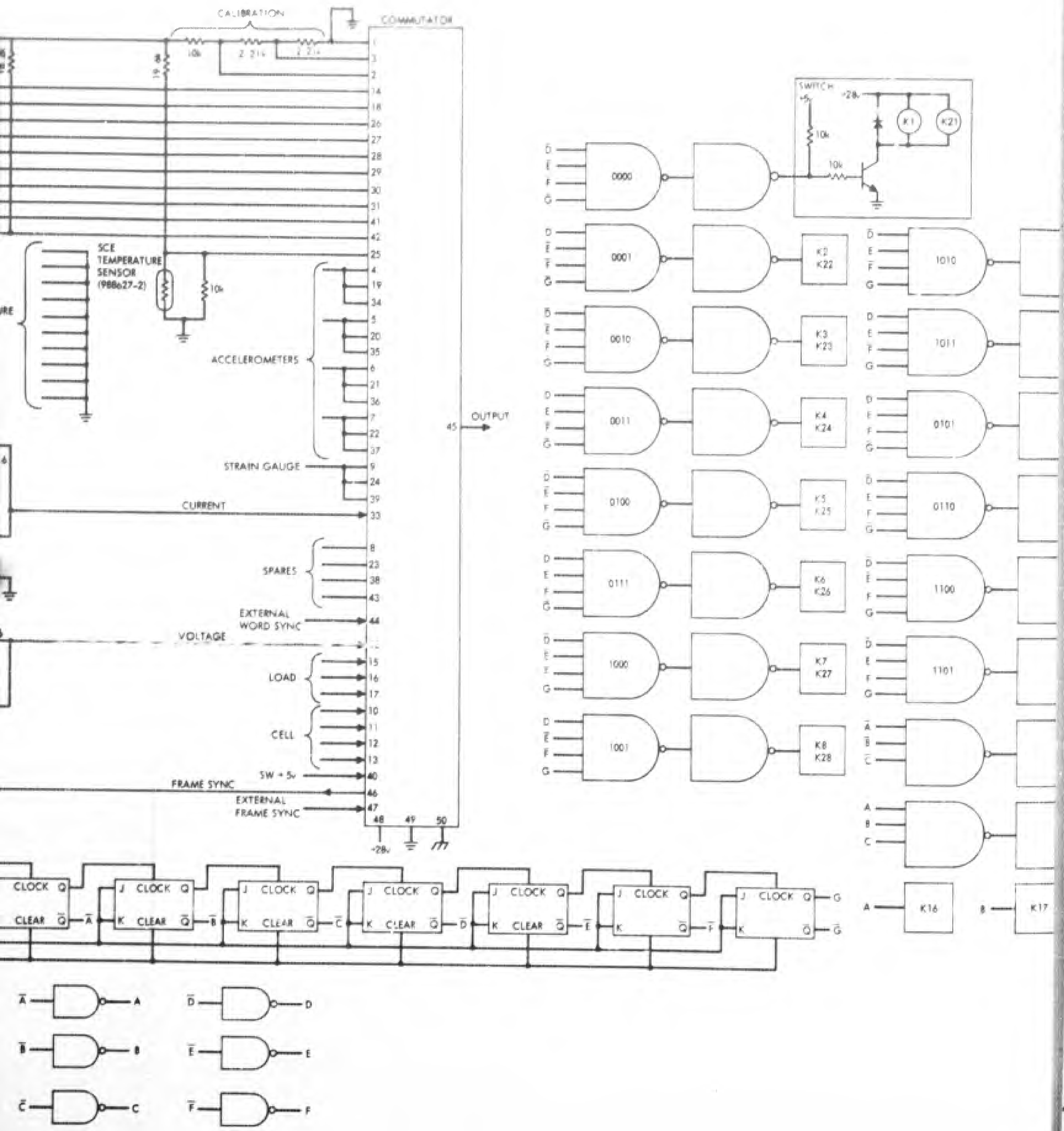
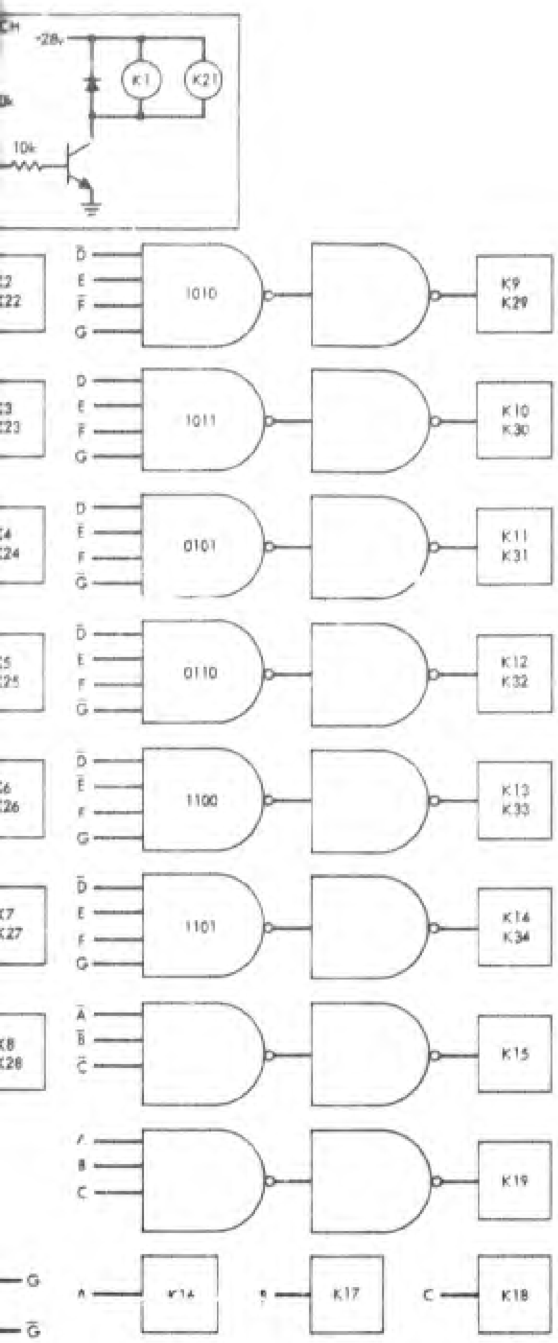


Figure 14. HS-207 Solar Cell Electronics Unit


CALIBRATION
COMMUTATOR
10k
2.21k
2.21k
SCE TEMPERATURE SENSOR (988627-2)
10k
ACCELEROMETERS
STRAIN GAUGE
CURRENT
OUTPUT
SPARES
EXTERNAL WORD SYNC
VOLTAGE
LOAD
CELL
SW + 5v
FRAME SYNC
EXTERNAL FRAME SYNC
+28v
SWITCH
+5v
+28v
K1
K21
0000
0001
0010
0011
0100
0111
1000
1001
1010
1011
0101
0110
1100
1101
K2 K22
K3 K23
K4 K24
K5 K25
K6 K26
K7 K27
K8 K28
K16
K17
J CLOCK Q
K CLEAR Q̄

B



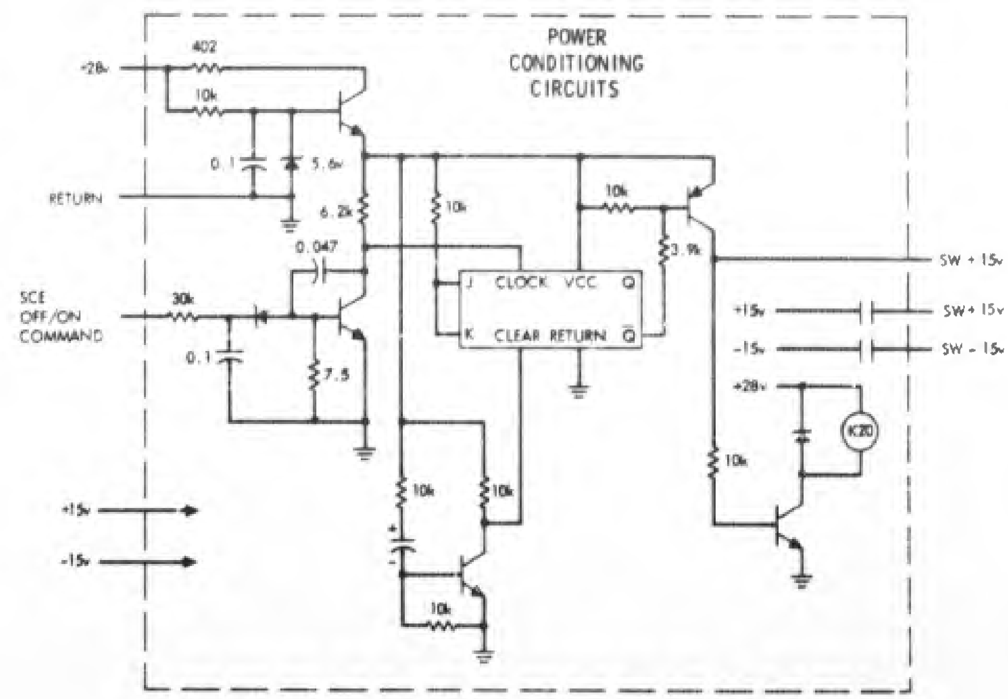
TOTAL TIME FOR EXPERIMENT:

$$\left(2\,\frac{\text{FRAMES}}{\text{LOAD}}\right)\left(8\,\frac{\text{LOADS}}{\text{CELLS}}\right)\left(4\,\frac{\text{CELL/MOD}}{\text{EXPERIMENT}}\right) \Big/ \left(\frac{125\ \text{FRAMES}}{45\ \text{SECOND}}\right) \cong 80\ \text{sec}$$

WITH 2 "SPARE" SELECTION TIMES FOR CELL OR MODULE, TOTAL TIME BEFORE EXPERIMENT RECYCLES IS ≈ 92 sec

LOAD SELECTION SEQUENCE				
LOGIC			RESISTANCE (INCL 1.50Ω WIRING AND RELAYS)	
			CELL	MODULE
0	0	0	∞	∞
0	0	1	4.5Ω	13.5Ω
0	1	0	4.0Ω	11.5Ω
0	1	1	3.5Ω	9.5Ω
1	0	0	3.0Ω	7.5Ω
1	0	1	2.5Ω	5.5Ω
1	1	0	2.0Ω	3.5Ω
1	1	1	1.5Ω	Ω

NOTE: ONE COMPLETE LOAD SEQUENCE OCCURS FOR EACH CELL (OR MODULE) SELECTED. EACH LOAD IS APPLIED FOR TWO COMMUTATOR FRAMES.



00021-14(U)

SECTION VIII

SYSTEM TEST

The system test effort and progress during this reporting period consisted of the following:

1) Completion of the preliminary qualification test plan
2) Completion of overhead camera tests
3) Completion of water table leak checks
4) Receipt of uthane floats
5) Completion of system test fixture design
6) Continuation of vibration fixtures design
7) Relocation of FRUSA systems test area
8) Completion of water table humidity tests
9) Continuation of overhead girder/camera mounting definition

DISCUSSION

The preliminary qualification test plan was completed and distributed on 15 November 1969. Comments and recommendations are being received from interested areas. The final test plan, scheduled for release in February 1970, will, of course, include integration of recommendations where appropriate.

The solar panel float guides, when installed on the water tables, form an interface seal, which must be watertight. This interface is approximately 0.5 inch below the water line. The tables were filled with water to the proper level during the overhead camera tests. The water remained in the tables for 48 hours without observable leakage.

Overhead camera tests were accomplished utilizing a Bell and Howell camera with a 10 mm lens (see Figure 15). The camera was mounted 20 feet above and normal to the surface of the water. The FISCA feasibility model was extended and retracted while 100 feet of film was exposed. The

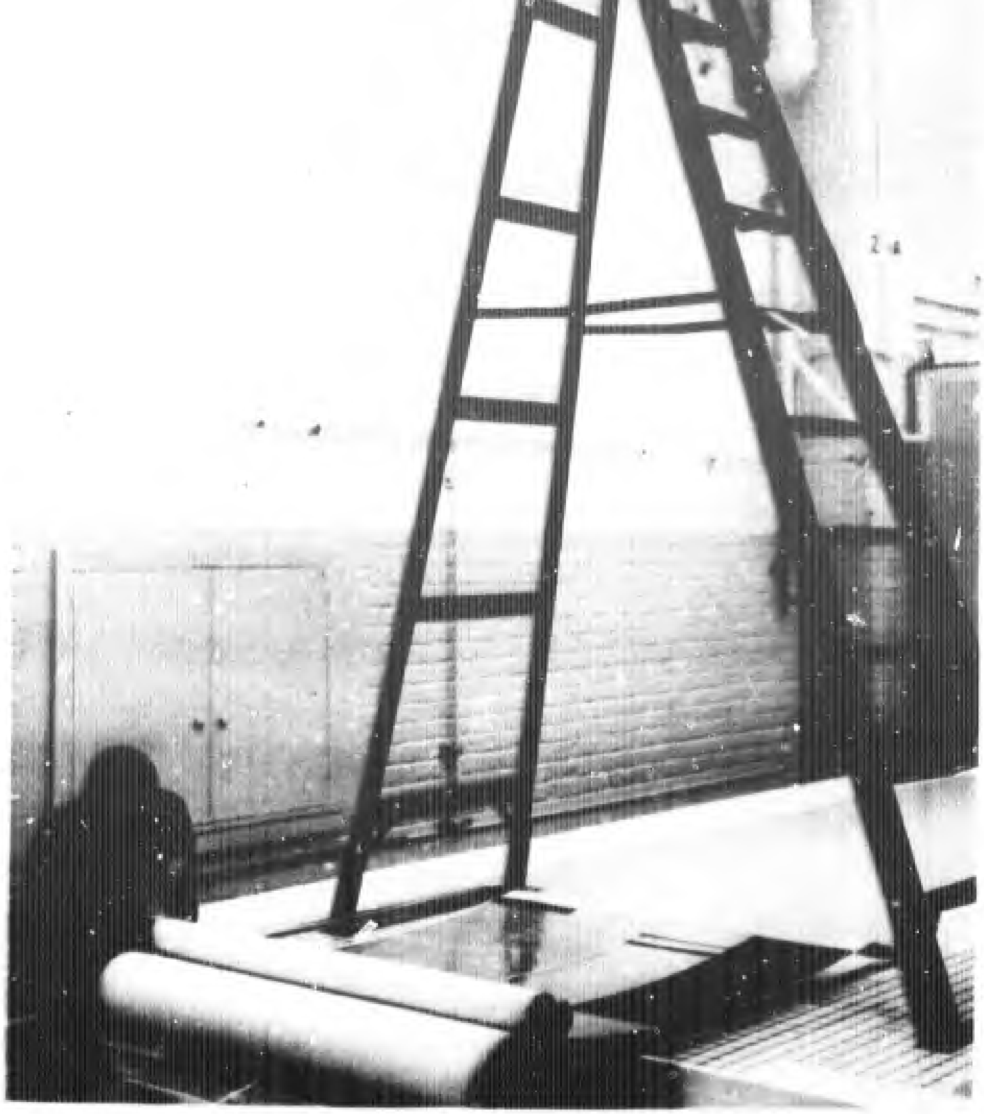


Figure 15. Overhead Camera Tests Using Bell and Howell 10-mm Lens (Photo A25356)

film has been reviewed by all interested activities and recommendations made. Three cameras with 13 mm lens are now planned to be used for the functional tests of the solar array subsystem.

The systems test fixture design has been completed. The design includes provisions for deploying the solar array in a horizontal plane, rotating the drum 90 degrees to allow extension/retraction and lowering to the proper water table level. Fabrication of the fixture will take place during the Fourth Quarter of Fiscal Year 1970.

The design of the three vibration fixtures was continued during this period. Three fixtures are being designed and built for testing of the three major subsystems. Fixtures for the orientation linkage and the power subsystems are relatively straightforward; however, because of the size and shape of the solar array, its fixture is rather complex. A simulation model has been devised for evaluation.

Since the FRUSA system tests were rescheduled at later dates, it was necessary, during the month of November, to relocate the test area. Relocation has been completed and the new area is in the same general high bay area at the Hughes El Segundo site.

To ensure that the solar array humidity limits are not exceeded during water table operations, a continuous recording humidity measuring was accomplished. The humidity sensor was located 0.5 inch above the water surface. Measurements were made over a 24 hour period. Data are presently being converted for analysis.

The FISCA feasibility model which is on loan from Wright-Patterson Air Force Base will be returned on 15 January 1970. This hardware has been extremely helpful in the development of the water table operations.

WORK TO BE PERFORMED

1) Publish final test plan

2) Complete vibration fixtures design

SECTION IX

RELIABILITY

During the last quarter, quality control plan HS-207/1001 has been updated. A requirement for source inspection on the orientation mechanism tachometer has been included.

Discussions with local Air Force quality representatives have continued. The following positive action will be taken to ensure reliability of the hardware:

1) Inspection of solar panel array fabrication to assure quality of materials and workmanship

2) Verification of panel segment electrical continuity by witnessing electrical continuity and performance test data

3) Inspect fabrication and functional test data of other electrical subsystem items as time permits to verify quality of materials, workmanship, and use of high reliability parts and electronic components

4) Examine and ensure adequacy of corrosion/contamination prevention and control during assembly operations, test operations, and storage

5) Inspect qualification model qualification test data on the flexible solar array and array subsystem components and verify proper test procedures, test levels, meter calibration, and accuracy

6) Inspect flight model acceptance test data on the flexible solar array and array subsystem components and verify proper test procedures, test levels, meter calibration, and accuracy

7) Verify calibration of temperature sensors, dynamic sensors, and other electrical sensors (standard reference cells and modules) as time permits

No change in the quality plan is anticipated.

About 1000 electronic parts have been received on the dock. These are proceeding through incoming inspection. Although only a sample of parts will be thoroughly tested, it will amount to a 100 percent parts inspection in most cases since the quantities of parts are so small.

Changes in the design of the drum mechanism and more detailed drawings of the entire system have made it possible to make a more accurate estimate of the reliability and maintainability. Work is proceeding on these estimates and should be completed during the next reporting period.

Planning of engineering and life tests are proceeding with the participation of the reliability engineer. Since a large number of rotations or operations are required for life testing, experience obtained during the engineering test will be part of the life test. For example, several hundred thousand rotations of the orientation mechanism are required to support the reliability prediction. Running tests at high and low temperatures although primarily conducted to find out how the mechanism will behave at these temperatures will be considered part of the life test.

WORK TO BE PERFORMED

1) Source surveillance of high reliability to parts to assure that they conform to the high reliability part specification

2) Incoming inspection of parts

3) Inspection of qualification model parts

4) Complete updated maintainability prediction

5) Complete updated reliability prediction

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13. ABSTRACT

The main activities on the Flexible Rolled-Up Solar Array (FRUSA) program during the sixth quarterly reporting period consisted of completion of the detailed drawings of all the FRUSA components. Most of the drawings have undergone stress and dimensioning checks and have been released to manufacturing for procurement or fabrication of components and parts. The supplier of the boom actuator mechanism has completed final tests of the development test unit prior to shipment of the unit. The unit was received by Hughes on 20 December 1969. The solar cell manufacturer has fabricated the cell qualification lot,and is on schedule for the required January delivery of the first qualification model cells. The average power output is slightly higher than the specified value.

Test and development programs on various system components including panel roll-up, cushion, panel thermal shock, and battery/charge controller have been successfully completed. Design reviews on each of the FRUSA subsystems were held prior to initiation of the qualification model drawing release phase which was initiated during this reporting period. The design of the subsystems was deemed to be satisfactory.

A Preliminary Qualification Test Plan has been completed and the Quality Assurance section of Specification DS 30992-001 "Performance, Design, and Product Confirmation Requirements for HS-207 Flexible Rolled-Up Solar Array Experiment, Qualification Model" and of the "Performance, Design, and Product Confirmation Requirements for HS-207 Flexible Rolled-Up Solar Array Experiment, Flight Model" have been completed and submitted to Wright-Patterson Air Force Base for approval.

A series of meetings were held at SAMSO and Aerospace on 13 and 14 November 1969. The purpose of the meetings was to familiarize the attendees with the plans of the 71-2 flight and to update each experiments' requirements document. These documents have been included in the RFP issued by SAMSO on 16 December 1969 for the integration of four experiments, including FRUSA, and for furnishing the spacecraft.

14. KEY WORDS	LINK A		LINK B		LINK C	
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